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UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. Krug, Secretary

FISH AND WILDLIFE SERVICE
Albert M. Day, Director

Special Scientific Report No. 59

Investigations of the Oyster Reefs of Mississippi, Louisiana, and Alabama Following the Hurricane of September 19, 1947.

by

James B. Engle

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Explanatory Note

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Aquatic Biologist
Branch of Fishery Biology

I. The Damage to the Oyster Reefs in the State of Mississippi caused by the Hurricane.

II. A Report of the Investigation of the Oyster Reefs of the State of Louisiana Following the Hurricane.

III. A Report of the Investigation of the Oyster Reefs of the State of Alabama Following the Hurricane.

I. The Damage to the Oyster Reefs in the State of Mississippi caused by the Hurricane.

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Introduction

The Congressional delegation from Mississippi, with Congressman William M. Colmer as the spokesman, urged an immediate survey of the Mississippi oyster reefs to determine the extent of the damage to the shellfish and the shellfish bottoms by the hurricane of September 19, 1947, for the purpose of recommending the steps necessary for a program of early rehabilitation for the reefs. Mr. Colmer, with information based on the results of a tentative inspection of these bottoms early in October by the Mississippi Seafoods Commission, presented the need for this emergency survey to the Director of the United States Fish and Wildlife Service, Mr. Albert M. Day. Mr. Day recognized the urgency of the request and authorized the investigation, which began on October 31, 1947, and continued until November 29, 1947.

The hurricane which swept parts of the coast of the Gulf of Mexico inflicted its maximum fury on the waterfront of Mississippi. The high winds and high water destroyed most of the beach installations, as well as the lighthouses and channel markers in the immediate vicinity of the shore. The turbulence of the rapidly rising water was further agitated by 90 to 100 miles an hour winds, and under these circumstances it was reasonable to expect some damage to the oyster reefs in the shallow waters adjacent to this shoreline.

The shops and packing houses processing oysters were almost all destroyed by the storm, as well as many of the boats used in the taking of oysters from the reefs. Through the help of the American Red Cross and several Federal agencies, boats and floating equipment were materially restored or replaced for the owners. Steady gains are being made in the rebuilding and re-outfitting of the destroyed or damaged shops. Fortunately, some relief was afforded the boatmen by the exceptionally good run of shrimp which were caught and processed by many who depended on the water industry for a livelihood. When the run of shrimp in the protected waters is exhausted, and that will be soon, this same group of people will be expected to turn their activities to oyster catching and processing. This survey and one made earlier by the State indicate the number of marketable oysters available from the Mississippi reefs is at present negligible, and the supply from neighboring States is apparently inadequate to furnish enough to keep the canning factories and the raw oyster shops operating.

The pertinent facts concerning the period, the force and the extent of the hurricane were collected by the staff of the United States Weather Bureau in New Orleans, Louisiana, and published by Mr. Ralph Sanders (1947) of that office. Summarizing the report by Mr. Sanders may help to picture the conditions suffered by this area on September 19. Hurricane warnings were issued by the above Weather Bureau Office

at 1:15 p.m., September 18, for the area west of Pensacola, Florida, to Morgan City, Louisiana. The center of the storm was located by air reconnaissance this same morning at 11:45 to be 195 miles south of Apalachicola, Florida, and was moving north-northwestward at about 15 mph, but the speed of translation of the hurricane increased during the night to about 18 mph. Winds reached hurricane force on the Mississippi coast from Pascagoula to Pearlington by 5:30 a.m., September 19. The center of the storm passed to the westward of Mississippi through the city of New Orleans. The area of hurricane winds, however, was greater to the north and east of the center than to the south and west. At the center the winds were about 25 mph. In Table 1, the available information on winds, tides and pressure at coastal points in Mississippi is tabulated. Sanders reported the area of greatest winds in the following statements:

> "The area along the Mississippi coast west of Pascagoula to the Lake Borgne-eastern Lake Ponchartrain-Covington area not only experienced the strongest winds of the hurricane, but also the greatest duration of the hurricane force winds."

He further states about the rise of the waters as follows:

> "In addition to the strength and duration of hurricane force winds in the area mentioned above, the waters of the Gulf of Mexico were caught up by the hurricane winds and carried into the Mississippi Sound where they piled up on the shore, moved into Lake Borgne, and swept inland some distance. The highest water reported was at Chandeleur Light about 14 feet, with the tide along the Mississippi coast rising to about 9 feet at Pascagoula, 10 to 12 feet westward to Pearl River (which marks the Mississippi-Louisiana boundary line 1/) and about 8 feet in the Lake Catherine-Chef Menteur area. It is evident that the water began to rise while hurricane winds from the northeast were being experienced in this area, or that the winds reached hurricane force prior to the highest water. The rise in the water was fairly rapid, but it definitely did not come in as a tidal wave, the rise beginning at 7:30 a.m., and reaching highest level at 10:00 a.m.,- 2½ hours later at Bay St. Louis.
>
> "It has been extremely difficult to arrive at a reliable estimate of the monetary loss caused by this hurricane. Using all available information, damages in Louisiana were probably about $24,000,000, and in Mississippi about $29,000,000. Of the total damages in Louisiana it has been estimated officially that $10,000,000 damages occurred in Orleans Parish".

1/ Author's note.

Table 1.

Winds Tides and Pressure at Coastal Points in Mississippi

During the Hurricane of September 19, 1947. 1/

Weather Stations	Maximum Wind Velocity direction-time		Hurricane Force Wind began-ended		Hours Wind Over 75 mph.	Highest Tide feet-time - began			Rainfall in inches
Pascagoula	85 E 2/	7:30	5:30	7:30	2 3/	9	10:00	--	--
Biloxi	90 E	9:00	5:30	9:00	3½	12	10:00	4:00	--
Gulfport	90 E	9:30	5:30	10:00	4½	12	10:00	--	--
Bay St. Louis	100 NE	9:00 4/	5:30	11:00	5½	12	10:00	7:00	8.4
Pearlington	100 NE	10:00	5:30	11:00	5½	--	--	--	5.45

1/ From a report written by Ralph Sanders and issued immediately after the hurricane by the U. S. Weather Bureau Office, New Orleans, Louisiana.

2/ Means estimated or calculated from available data.

3/ In addition to the period of hurricane winds, the wind velocity exceeded 38 mph. for 6 hours.

4/ The lowest barometric pressure recorded was at Bay St. Louis at 10:30 a.m., and it was 29.10 inches.

Note: All time referred to in this table is a.m.

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The Weather Bureau report contained an analysis of property damage compiled by the American Red Cross which is tabulated below:

State	Homes		Other Buildings		Boats	
	Destroyed	Damaged	Destroyed	Damaged	Destroyed	Damaged
Miss.	524	7,557	416	962	42	168
La.	396	4,111	466	1,784	-	-
Totals	920	11,668	882	2,746	42	168

Deaths resulting from the hurricane numbered 22 in Mississippi and 12 in Louisiana, a total of 34.

Information about the extent and production of the oyster reefs of Mississippi is meager and represented by limited biennial reports prepared by the Mississippi Seafoods Commission and its predecessors. These reports dealt mostly with the financial transactions of the Commission. Of further assistance in gathering background data for this survey was a report by J. H. Weatherby, Biologist with the U. S. Bureau of Fisheries (now the Fish and Wildlife Service) of a survey of the oyster bottoms in Mississippi Sound made in 1926-7 and submitted in 1930. The report included a chart roughly indicating the general positions of oyster producing bottoms in Mississippi. This report stated that the locations of oyster reefs in Mississippi were not charted as such and it was therefore difficult to assign definite boundaries. Weatherby estimated more than 100 square miles of oyster bottom, located mostly west of Biloxi to the Louisiana State line, with additional beds in Back Bay, Bay St. Louis and in Mississippi Sound in the vicinity of Pascagoula. He also presented hydrographical and biological data of a limited nature.

A more recent report was written by Dr. A. E. Hopkins, formerly Aquatic Biologist with the U. S. Fish and Wildlife Service and in charge of oyster investigations in Gulf Coast areas, in which he discussed some of the damage to the Mississippi oysters by the opening of the Bonnet Carre spillway in 1945. The report was submitted to the Director of the Fish and Wildlife Service in 1946. Hopkins recorded an almost total loss of the oysters on the reefs in the western part of the Mississippi oyster producing grounds. Mr. Meco Filipich, Chief Seafoods Inspector of Mississippi, in his monthly reports to the Commission in the fall of 1945 stated that a good spatfall had caught on the shells and boxes of the oysters killed the preceding spring by the fresh water from the opening of the Bonnet Carre spillway. In his later reports, early in September 1947, he again mentioned the growth and abundance of the set of the previous two years. In addition to the natural set considerable seed had been transplanted from the Pascagoula seed beds to

the tonging areas near Biloxi and westward to Waveland. The disposition of this seed and also of shells planted during 1945-6-7 will be discussed in its relation to the losses sustained by the State as a result of the hurricane.

Description of Mississippi Oyster Producing Waters

A physical description of Mississippi Sound may aid in developing the discussion of the field work. The Sound is a narrow body of shallow water extending from Mobile Bay on the east to Lake Borgne on the west. The major part of its northern coastline is in Mississippi with a small section in Alabama. The southern boundary is formed by a line of five long narrow islands and sand bars which separate it from the Gulf of Mexico. Between the islands are channels or passes two or three miles wide that connect the Sound with the Gulf. Four of the five islands are in Mississippi, and it is around the westernmost one, Cat Island, that the State has its most valuable oyster reefs. The Sound is approximately 70 miles long and varies between 8 and 12 miles in width. Except for a few dug and natural channels its depth is less than 20 feet, and where most of the oysters occur it will average less than 10 feet deep at mean low water. The total area is slightly more than 700 square miles, 80 percent of which is in the State of Mississippi.

Entering the Sound along the northern coastline of Mississippi are three rivers, from east to west, the Pascagoula, the Biloxi and the Jourdan. Each of these rivers widens into a large bay as it enters the Sound. At the mouth of the Pascagoula River the bay is a series of delta-like openings called lakes connected by passes and bayous. The principal ones are Lake Masse, Lac La Buche, Irvin Lake, Krebs Lake, West River and Middle River. Oysters grow in most of these but because of the shallow water they form cooner reefs of densely clustered small oysters. The mouth of the Biloxi River is called Back Bay and Biloxi Bay. The portion nearest the mouth of this body of water has usable oyster reefs. Across the entrance of Biloxi Bay is Deer Island, a wooded piece of land several miles long. The water between it and the mainland contains important and extensive oyster beds. The mouth of the Jourdan River forms Bay St. Louis, and here also many oyster grounds exist.

At the extreme eastern end of the Mississippi mainland is a small body of water, Pt. aux Chenes Bay, that is formed by a series of islands, Grand Batture Islands, running southwesterly from the mainland. Some oysters are found there but the limited production from this shallow bay is not considered very important by the Mississippi seafood authorities. At the extreme western part of Mississippi at the entrance of Lake Borgne is another small bay, Heron Bay, in which

oysters grow naturally, and where the State also plants shells and seed. Its proximity to Lake Borgne exposed it to the fresh water that came into the area when the Bonnet Carre spillway was opened into Lake Ponchartrain and overflowed into Lake Borgne in 1945.

In Mississippi Sound are located the main oyster reefs and plantings as well as the seed beds. In the area off the mouth of the Pascagoula River are large reefs of oysters in shallow water. Oysters set prolifically but do not grow to usable marketable size. The depth of the layer of shell on these reefs has been sufficient to keep enough cultch present for oyster setting. The chief value of the area, however, is in its production of seed. The State of Mississippi drew upon these beds for seed. At present there is a large amount of it ready to be transplanted when the State undertakes a program of rehabilitation of the Hurricane damaged reefs. Weatherby (1930) demonstrated that these oysters, when moved offshore in the same general area and elsewhere, where the water is deeper, grew rapidly to marketable size if the clusters were thinned out by transplanting. Between the mainland at Pascagoula and Horn Island, one of the islands forming the southern boundary of Mississippi Sound, is Round Island where some oyster reefs exist and good oysters are produced in small quantity. Extensive plantings of seed were made in the vicinity of Graveline Bayou along the western edge of the Pascagoula tonging area. In the region near Biloxi, in addition to the reefs and plantings in Back and Biloxi Bays, the State, in the spring of 1947, planted seed oysters on the sticky bottom south of Deer Island. From this point westward to Long Beach there were no areas recognized by the State as commercially producing oyster reefs although small patches of oysters could be seen from the shore growing as cooner reefs exposed at low tide.

From Long Beach westward to the Louisiana waters, were located the main oyster producing bottoms. To simplify the description of this area, it will be considered in two sections, (1) that of the inshore tonging area, and (2) the offshore dredging reefs. The position of the tonging areas is established by law which states under the authority of Section 6912 of the Mississippi Code of 1930, part 6880, as follows:

> "Dredging limits. It shall be unlawful for any person, firm or corporation to catch or take oysters by means of dredging in any of the following waters in the State of Mississippi:
>
> "(a) The Bay of Biloxi. (Back Bay)
>
> "(b) Water of the bay of St. Louis north of the Louisville and Nashville railroad company's bridge.

"(c) In the limits beginning at a point one and one-quarter miles from the shore in the City of Bay St. Louis at the Louisville and Nashville railroad company's bridge, thence southerly following the meanderings of the shore along Bay St. Louis and Waveland and one mile therefrom to the head of of Waveland Avenue; thence westerly to the shore of said Waveland Avenue.

"(d) In the limits beginning at a point on the Mississippi seashore at Jeff Davis Avenue, in Long Beach, and extending south a distance of one and one-quarter miles; thence west, following the meanderings of the said seashore one and one-quarter miles distance from same to the western corporate limits of the city of Pass Christian thence north to the seashore at the head of Boisdore Avenue in said city.

"(e) In the limits lying east of a line projected from the west bank of the mount of Bayou Graveline in Jackson County to Round Island Lighthouse and north of a line projected due east from Round Island Lighthouse to the Mississippi-Alabama State line".

This restricts an area of approximately 45 square miles to the taking of oysters with tongs. Oyster reef does not cover all this area for there are sloughs of mud between the hard and sticky bottoms containing the oysters. An estimate of the actual oyster bearing bottom in the tonging area would include about 20 square miles of producing reef. In no area except at Pascagoula was there a dense natural growth of oysters. The State made some effort to supplement the natural set on the reefs within the tonging grounds by planting seed, and in some cases shell, to keep the density of the oyster population sufficient for the tongers working the beds to earn a living. It is from the tonging grounds that a large part of the raw trade or barrel stock oysters for shucking and half-shell is supplied.

Dredging for oysters may be employed on all public grounds except those listed above. The main dredging grounds are located in the vicinity of Cat Island and westward to the Mississippi-Louisiana State line. This area from the tonging limits south and west to the above State line constitutes the major part of the 100 square miles of oyster reef mentioned by Weatherby (1930).

Production of Oysters

A resume of the production of oysters in Mississippi compiled from the records on file in the office of the Mississippi Seafoods Commission showed 531,420 barrels processed during the period from

July 1, 1945 to June 30, 1947. In the several biennium preceding the above the production was as follows: for 1943-1945, 561,864 barrels; for 1941-1943, 1,040,438 barrels. The Secretary of the Mississippi Seafoods Commission estimated, in addition to the above production, there were about 50,000 barrels of oysters brought in each year by the small skiffs and peddled to local retail trade which were not shown on the records because of the difficulty in collecting the barrel tax.

Equipment and Methods used in this survey.

The equipment and methods used in this investigation are the standard tools of the commercial dredger with very little modification of the usual system of operation. The two boats of the Mississippi Seafoods Commission were employed. The cabin cruiser, George R. Smith, the Mississippi Seafoods patrol vessel, was used as a floating headquarters for the field work, and furnished quarters for the survey party when it was away from Biloxi. The motor dredge boat, Uranus, equipped with power dredges was used to sample the reefs.

The dredge frame was heavy and supported a chain and cord bag which when filled held approximately 1 barrel or 3 bushels of material. The frame had a 42-inch bar containing 16 teeth 3 inches long placed $2\frac{1}{2}$ inches on centers. The dredges, whose efficiency was increased by a heavy chain dredge line, were hauled on a friction hoist run by a power take-off from the main engine of the boat. The boat maintained a speed of about 4 miles per hour while dredging. Because it was impossible to examine samples as fast as two dredges could collect them only one dredge was used at a time.

The consistency of the bottom was checked continually by sounding with a pole and classified as follows:

Classification	Symbol[1/]	Description
Hard reef	H. R.	solid oysters and (or) shells
Sticky reef	St. R.	oysters and shells on or in stiff mud
Sand	Sd.	usually without oysters or shells
Sticky mud	St. M.	stiff mud without oysters or shells
Soft mud	S. M.	pole penetrates easily - no oysters

On some of the soft mud bottoms the pole, after penetrating from 6 to 12 inches, struck hard reef. The dredged material from such places often contained "boxes" of recently killed oysters.

1/ Symbols used in Table 4.

Because there were no charted boundaries for most of the designated oyster areas except the prescribed limits of the State tonging grounds all the approaches to the oyster bottoms had to be explored with the pole to locate the edges of oyster reefs. Most of the reefs were surrounded by or separated from each other by soft mud leads or sand bars. The Chief Inspector of the Mississippi Seafoods Commission, Mr. Meco Filipich, was responsible for locating the general position of the reefs examined during this survey.

Water samples were taken at most of the reefs and planted oyster bottoms studied during this investigation. The salinity determinations were made by hydrometers certified by the U. S. Bureau of Standards. The hydrometer readings were corrected to salinity in parts per thousand by reference to the tables of Knudsen (1901). The relative turbidity of the water was noted when the salinity samples were taken. Temperature of the water was determined frequently but not at all reefs.

When dredging for samples of bottom material the following procedure was used: first, the length of the drag was timed; then the volume of the catch was estimated in barrels for each drag; and finally the contents were evaluated to the percent of live oysters, dead oysters ("boxes") shells and debris; and a listing of the predators and fouling organisms. Some oysters were opened at each reef or sampling area to determine the condition of the meats, the presence or absence of the crystalline style, the amount of gonad material present and the condition of the inner surface of the shells with regard to the occurrence of the mud blisters of Polydora, and the perforations made by the boring clam or boring sponge. Dead oysters considered were only those whose empty shells were still joined by the horny hinge. The dead oysters' shells were examined for evidence of drilling by the conchs.

The approximate density of the oyster population was calculated in the number of barrels per unit area. The area covered was determined by the square yards the 42-inch dredge dragged per unit time. This size dredge covered 137 square yards per minute when dragged at the rate of 4 miles per hour. Comparing the catch in barrels by this method made it possible to tell the relative distribution of oysters and other bottom material on the oyster reefs in Mississippi examined at this time.

Through the efforts of the Secretary of the Commission, Mr. F. W. Elmer, records of the State oyster cultivation program for several years prior to the hurricane were assembled to supplement the information being collected on the present condition of the reefs. The records

listed the planting of 243,767 barrels of shells distributed in the following annual amounts: for 1944, 38126; for 1945, 108,049; and for 1946, 97,592. No shells were planted in 1947. For the same period 81,258 barrels of seed oysters were distributed as follows: for 1944, 16,767; for 1945, 22,822, and for 1947, 41,669. No seed was transplanted in 1946. The location of the plantings is shown in Table 2.

Salinity, Temperature and Turbidity.

The oyster is a brackish water animal that can tolerate wide fluctuations in salinity or salt content of the water. There are limits, however, beyond which the salinity must not change if the oyster is to remain alive, reproduce and "fatten". It is essential, therefore, to check the salinity conditions from time to time of the waters in which oyster populations show an abnormal mortality, the retarding of the usual growth, the reduction of the expected setting rate, or the failure of the meats to "fatten". Drastic lowering of the salt content by the influx of fresh water has been recorded as a major cause of heavy mortalities in oyster populations. These conditions have been observed on the oyster bottoms in some places along the Atlantic coast and the Gulf of Mexico. Formal records indicating this are available (Beaven, 1946; Engle, 1946; Galtsoff, 1930; Gowanloch, 1946; Hopkins, 1946; Moore, 1913; and Ritter, 1895). The reports of Gowanloch and Hopkins (loc. cit.) discuss the heavy mortalities among oysters in Mississippi and Louisiana resulting from the influx of fresh waters into Mississippi Sound when the Bonnet Carre spillway was opened March 23, 1945, to relieve the flood conditions on the Mississippi River in and around New Orleans. Heavy losses occurred among the large oysters on the reefs in the western portion of the Mississippi oyster areas. The water was reported absolutely fresh at that time, and low salinities prevailed for several months thereafter. After the spillway was closed and the salt content of the water increased, a heavy setting occurred on these same reefs so recently damaged. The setting supplemented by further setting in the following years of 1946 and 1947 repopulated the reefs. This did not alleviate the initial loss to the industry sustained by the mortality of early 1945, but it did raise some hope that by 1947-8 some of this set would reach maturity and be available to the industry. Since 1945 the salinity must have been sufficiently high to permit these oysters to live, grow and reproduce normally. Weather Bureau reports substantiated such a contention by showing no sustained abnormal amount of rainfall in the area for this period.

Rainfall at the time of the hurricane was heavy in the Mississippi coast region, but the northwest direction of the storm with the

Table 2.

Seed and Shell Transplanting, State of Mississippi Program 1944 - 1947.

Location	Barrels Seed				Barrels Shells			
	1944	1945	1946	1947	1944	1945	1946	1947
Bayou Cassatte		750		N			N	
Pascagoula River, West Bank			1805	o			o	
Middle River		650						
West River			6760	S			S	
Round Island	1500			e	1000		h	
Bayou Graveline	650		1417	e	591		e	
Ramsey Point		6300	4500	d			l	21000
Ocean Springs	3550	23150	17297				l	3500
East End Deer Island	12300	22650	8060	P				2019
West End Deer Island		12360		l	1000		P	
South of Deer Island				a			l	1650
Back Bay	8350	1500	11618	n			a	
Coast Guard Station (Ott's Reef)	5026			t			n	
Belle Fountaine Point				i	1000		t	
North Railroad Bridge, Back Bay			9677	n			i	3500
Camp Grounds			2040	g			n	
Kittywake - Long Beach			4980			1650	g	
Pass Christian Tonging	1750	5000	9478	i	1000	1238		
Pass Christian Dredging	5000			n			i	
Pass Christian Tonging, E. of Factory			940				n	
Bay St. Louis Tonging		35689	13000	l	1176	608		
Bayou Caddy - Waveland			2060	9	1000	1616	1	
George Smith Reef			3420	4		3892	9	
Cat Island			540	7	1000		4	10000
Pass Marianne					4500	6586	6	
Telegraph Reef					4500	5820		
Calico Reef						1412		
Sub-totals:	38,126	108,049	97,592		16,767	22,822		41,669
Totals:			243,767					81,258

accompanying high tide dissipated any fresh water that may have affected the oysters. It may be assumed that dead oysters found in the area of storm damage were killed by some other condition than low salinity.

Salinities from most of the Mississippi waters were higher in the eastern part and decreased gradually westward. There were some exceptions to this general condition when the samples were taken near the mouths of the rivers and bayous, where salinities were slightly lower than the trend would indicate. The same was generally true of the offshore waters except that the decrease was much less apparent from east to west. At no station was the salinity low enough to be detrimental to the existence of oysters (Table 3).

The relation of salinity to the presence of the conch, Thais sp. is of considerable importance. Conchs were found in most of the dredged samples of bottom material from the inshore stations east of Biloxi, while they were generally absent from the inshore stations west of this point. Most of the offshore stations from east to west had conchs in the dredged samples. Where to draw the salinity line that inhibits the existence and development of the conchs is hardly possible from the limited salinity data collected during this survey, but it is reasonable to suppose that some check exists to limit the distribution and activity of this predatory snail in the waters inshore and west of Biloxi. This check is no doubt imposed by the lower salinity that exists in the area temporarily when the spring rains reduce the salinity proportionally more here than elsewhere. The control of the conch may in some measure account for the higher oyster production from the western reefs.

Bottom water temperatures were observed on all the trips to the oyster reefs although a temperature was not taken at all the stations. From the beginning of the month, November 4, to the end of the field observations, November 18, there was a drop in the water temperature from 20.5° C. to 16° C. (68.9° to 60.8° Fahrenheit). There was a corresponding drop in air temperature as the month progressed. The water was sufficiently warm to permit active feeding of the oysters in this area throughout the course of the investigation. With this relatively warm water the popular watermen's theory that oysters would not "fatten" until cold water prevailed was borne out by the generally thin condition of the oyster meats.

The water was moderately turbid at most of the stations (Table 3). Clear water was observed only in the deep water off Cat Island and in the region near Round Island Beacon. When the suspended material settled out in the water samples after standing it was found to be a very fine brownish silt. Apparently this silt does not settle out to any

Table 3.

Salinities, Temperatures and Turbidity of the Water in Mississippi Sound During November, 1947

Stat.	Place	Date 1947	Depth in ft.	Salinity °/oo	Temp. °C.	Turbidity
	East of Biloxi - Inshore	Nov.				
35	Pascagoula Cooner Reef	17	4	27.16		moderate
36	Pascagoula Planted Bed	18	4	16.67	16.1	heavy
34	West River Mouth Cooner Reef	17	3½	25.38		moderate
39	Round Island Beacon	18	7	26.87		clear
33	Bayou Graveline	17	5	17.50	16.5	moderate
40	East of Belle Fountaine Point	18	9	21.35		light
38	Ramsey Point Shell Planting	18	6	15.85		heavy
3	Ramsey Natural Reef	4	5	23.96	20.4	moderate
	West of Biloxi - Inshore					
13	Kittywake Planting	5	7	18.03		heavy
23	Pass Christian Tonging	13	11	19.00	15.7	heavy
10	Hornet Reef	5	0	14.11	20.8	moderate
	" "		12	18.34	21.0	moderate
17	Bayou Caddy	6	6	14.28	20.5	heavy
20	Heron Bay East	7	9	17.54		moderate
19	Heron Bay West	7	8	14.71	20.3	moderate
	Heron Bay in Channel	7	29	18.42	20.7	moderate
	East of Biloxi - Offshore					
4	Planting South of Deer Island	4	5	27.48	20.5	moderate
	West of Biloxi - Offshore					
32	Buoy Reef	14	10	26.80		moderate
26	Cat Island Channel	13	21	25.59		clear
31	Fletcher Keys	14	7	22.81	16.1	moderate
24	Geo. Smith Reef	13	8	20.17		moderate
27	Pelican Keys	13	8	24.03		moderate
30	Umbrella Keys	14	13	23.13		moderate
25	Pass Marianne Light	13	6	19.60		moderate
28	North of Pass Marianne Light	14	14	20.35	16.0	moderate
29	Telegraph Key	14	7	22.99	16.2	moderate

great extent on the oyster reefs, but is kept in suspension by the movement of the water. For the most part the oysters dredged were free of any deposit of a similar nature when they were brought on deck. This light silt in fairly stable suspension is not likely to be a hazard to the oysters.

Examination of the Mississippi Oyster Reefs, 1947

To cover this area 40 sampling stations were visited. From 3 to 20 drags of the dredge were made at each station. The average time for each drag was 5 minutes and the average amount of material caught per drag was adjusted to the 5 minute drag for comparison. The area covered in the 5 minute drag was calculated to be 675 square yards. The total area of the bottom actually covered by the dredge in sampling the reefs was 155,221 square yards. A summary of the dredging and samples collected is found in Table 4. For a more comprehensive grasp of the conditions found on the reefs during the survey, a narrative description of the individual station areas is given. The stations are considered in groups found in the regions arbitrarily dividing the Mississippi oyster producing bottom, and described previously in this report.

I. Tonging reefs and plantings west of Biloxi to the Mississippi-Louisiana State Line.

a. Kittywake-Long Beach. Station 13 is located within the Pass Christian tonging area near its eastern extremity on a mixed bottom of sand and sticky mud. The State in the last 3 years scattered 4,980 barrels of seed and 1,650 barrels of shells to supplement the oysters growing in scattered lumps throughout the area. Twenty drags of the dredge for 10 minutes each averaged only about 1/6 of a barrel of material per drag which consisted of a few old oysters in clusters with some small and recently set oysters. All the planted seed and shells appeared to have been washed away or covered with sand. At present the bottom is in a depleted state and will need re-seeding or re-shelling to bring it back to a productive condition.

Polydora blisters were numerous on the inner surfaces of the shells and boring clams had riddled many of the older oysters. One small conch was caught but no drilled oysters were seen. A small amount of Bryozoa fouled the shells but did not appear to interfere with setting.

The meats were fairly thin, sex products were still present in the gonads, and the crystalline style was seen in most oysters

Table 4.

A Summary of the Dredging and Material Collected in Mississippi.

Station	Depth	Type of Bottom 1/	Number Drags	Time per Drag in Mins.	Area Covered By dredging in Sq.Yards	Total Amount Material Dredged	Amount Material per 5 min. Drag	Conchs	Live Oysters			Recent Oyster Mortality Per cent Dead
									Market	Small	Spat	
1.	5'	H.R.	3	3	1,233	2.0 bbl.	1.0 bbl.	many	few	many	many	75% large
2.	6'	H.R.	1	3	548	0.3 "	0.5 "	0	0	scarce	few	85%
3.	5'	S-St.R.	3	3	1,233	0.7 "	0.4 "	0	0	few	few	90%
4.	6'	H.S.	4	3	1,644	0. "	debris	0	—	—	—	—
5.	6'	S.M.	5	5	3,425	0.5 "	0.1 bbl.	0	0	few	few	99%
6.	5'	H.St.R.	3	5	2,055	3.0 "	1.0 "	0	few	many	many	10%
7.	5'	St.R-S.M.	3	5	2,055	0.7 "	0.2 "	0	0	few	few	75%
8.	5'	St.R-S.M.	7	5	4,795	3.0 "	0.4 "	0	scarce	many	many	75%
9.	6'	H.R.	12	3	4,932	12.0 "	1.7 "	0	scarce	many	many	8%
9. a	6'	H.R-S.	4	5	2,740	1.7 "	0.3 "	0	0	scarce	some	40%
10.	12'	H.R-S.M.	20	3	8,220	14.0 "	1.2 "	0	scarce	many	some	10%
11.	7'	H.R.	5	3	2,055	3.5 "	1.2 "	0	scarce	many	many	10%
12.	16'	H.R.	10	3	4,110	6.7 "	1.1 "	0	scarce	many	some	10%
13.	7'	H.R-S.	20	10	27,400	3.4 "	0.1 "	present	scarce	scarce	few	9%
14.	15'	H.R-St.R.	4	5	2,740	4.0 "	1.0 "	0	scarce	many	scarce	9%
15.	7'	S.M.	5	10	6,850	0.5 "	0.05 "	0	0	few	few	95%
16.	11'	S.M.	3	10	4,110	0.3 "	0.05 "	0	0	few	few	95%
17.	5'	St.R-S.	3	10	4,110	0.5 "	0.08 "	0	scarce	few	few	2%
22.	8'	H.R. S.	3	5	2,055	0.5 "	0.16 "	0	0	scarce	few	0
18.	11'	H.R. S.	4	6	3,288	0.7 "	0.14 "	0	few	few	few	7%
19.	7'	St.R.	6	8	6,576	1.0 "	0.10 "	0	0	scarce	scarce	15%

1/ See page 12 for classification of bottom

Table 4 - Continued.

A Summary of the Dredging and Material Collected in Mississippi.

Station	Depth	Type of Bottom 1/	Number Drags	Time per Drag in Mins.	Area Covered By dredging in Sq. Yards	Total Amount Material Dredged	Amount Material per 5 min. Drag	Conchs	Live Oysters			Recent Oyster Mortality Per cent Dead
									Market	Small	Spat	
20.	9'	St.R.	3	6	2,466	1.0 bbl.	0.27 bbl.	0	0	scarce	few	20%
21.		H.R.	4	5	2,740	2.8 "	0.7 "	0	0	few	many	4%
23.	11'	H.R.	3	5	2,055	2.2 "	0.7 "	0	few	few	few	8%
24.	8'	H.R.	4	6	3,288	3.1 "	0.64 "	present	few	many	many	5%
25.	6'	H.R.	7	5	4,795	7.0 "	1.0 "	0	scarce	many	many	8%
26.	21'	H.R.	3	5	2,055	3.0 "	1.0 "	present	few	scarce	few	60%
27.	8'	H.R.	1	10	1,370	0.7 "	0.4 "	present	few	few	few	5%
28.	14'	H.R.	12	5	8,220	12.0 "	1.0 "	0	scarce	many	few	5%
29.	7'	H.R.	12	4	6,576	12.0 "	1.2 "	0	few	many	few	3%
30.	13'	H.R.	2	3	822	2.7 "	2.2 "	0	few	many	few	3%
31.	13'	H.R.	5	4	2,740	5.0 "	1.2 "	present	few	many	scarce	3%
32.	10'	H.R.	4	4	2,192	4.0 "	1.2 "	many	few	few	few	5%
33.	5'	H.R.	7	5	4,795	4.0 "	0.6 "	present	scarce	many	many	25%
34.	3½'	H.R.	2	5	1,370	0.3 "	0.15 "	0	0	many	many	30%
35.	3'	H.R.	5	3	2,055	1.4 "	0.5 "	0	0	many	many	15%
36.	4'	H.R.S.	15	4	8,220	15.0 "	1.2 "	0	0	many	many	20%
37.	3'	H.R.	3	4	1,644	3.0 "	1.2 "	0	0	many	many	20%
38.	6'	St.R.	3	4	1,644	3.0 "	1.2 "	present	few	many	many	20%

1/ See page 12 for classification of bottom.

which indicated they were feeding actively.

b. Pass Christian Tonging Reef, (East End). Station 9a is located west of Kittywake and east of Pass Christian harbor on a hard sandy bottom. The State planted on the whole reef in the last three years 17,168 barrels of seed and 2,238 barrels of shell, of which 940 barrels of seed were placed at the eastern end. Planting was done by shovelling the material overboard while the boat moved slowly in a straight line, making the density of the planting 100-200 barrels to the acre. Four zigzag drags of 5 minutes each failed to locate any concentration of oysters. The dredge caught about 1/3 barrel of material per 5 minute drag. There were no market-size (3 inches long) oysters in the catch, but there were a few small ones. A fairly good set of 1947 spat was found on the shells, live oysters and boxes. Approximately 40 percent of the small oysters, exclusive of 1947 spat, had died recently. Sand covered most of the planted and natural stock. Considerable brush and debris were caught by the dredge. The bottom has relatively few live older oysters and will need seed and shell to make it active again, although the 1947 spat fall has started a natural move toward rehabilitation.

Fouling and destructive organisms were about the same as at Kittywake except that no conchs were in these latter samples.

The meats were fairly thin and the gonads filled with spawn. The crystalline style was present.

c. Pass Christian Tonging Reef (West End). Station 9 is located west of the Pass Christian harbor on a hard reef bottom composed of shells and oysters. The bottom was sampled by making 12 drags of 3 minutes for each drag. Market-size oysters were scarce but many small oysters, as well as many recently set, were present. A considerable quantity of loose shell was in the bottom material on which recent set had caught. This shell was not here before the hurricane and apparently had shifted from some other place. Except for the additional shell, this part of the reef did not seem to be seriously disturbed and with the quantity of oysters now present it should become productive for market within the next two years. Mortality was light with between 5 - 10 percent of the small oysters recently killed.

No conchs were found and no drilled oysters. Fouling was light except for a few shells and oysters invaded by the boring clam. Polydora was present in moderate numbers.

Oyster meats were good with "fattening" well advanced. Gonads were empty of mature sex products and the liver was mostly obscured by accumulated glycogen. The crystalline style was present in all of the oysters opened.

d. Henderson Point Tonging Reef. Station 11 is located at Henderson Point on the east side of the entrance to Bay St. Louis and west of Pass Christian and Hornet Reefs in 7 - 9 feet of water. The bottom was similar to that of the neighboring tonging reefs, mostly hard shelly reef mixed with some debris consisting of sticks and clumps of marsh grass, probably brought in during the recent storm. The area was sampled by making 5 drags of the dredge for 3 minutes at each drag. The dredge came in about 2/3 full of bottom material at each haul, making a total sample of 3.5 barrels. Most of this material was small live oysters with an abundant late 1947 set attached to them. Marketable-size oysters were scarce.

Recent mortality, mostly of oysters killed by mudding, did not exceed 10 percent of the population. No conchs or drilled oysters were recovered from the sample.

The condition of the oyster meats was good although a small amount of spawn was still present in the gonads. The crystalline style was found in all oysters examined.

Shells and oysters were not very fouled except for a few boring clams in the older shells and oysters.

e. Pass Christian Tonging Reef Addition, (South of the main reef). Station 23 is located due south of the Pass Christian Harbor and adjoining the southern prescribed line of the regular tonging area. The bottom, for the most part, was hard reef with an occasional soft mud slough. The dredge was dragged 3 times for 5 minutes on each drag to sample the bottom. Bottom material was more abundant offshore than along the inner line of the reef. Oysters were scarce and scattered, with a few recent spat on some of the shells and oysters. Shells of the same type as were found at Station 9, were present in quantity. A few boxes of all ages represented a recent mortality of about 8 percent.

Shells were old but not badly fouled. Boring clams were present, together with a small amount of boring sponge. Neither conchs nor drilled oysters were found. Polydora was scarce.

Oyster meats were good and beginning to "fatten". Gonads were almost expended, and the crystalline style was present.

f. Bay St. Louis Tonging Reef. Station 15 is located just west of St. Louis Bay and south of the railroad bridge in 7 feet of water. There was a semi-soft layer of mud 8 to 12 inches thick over a sticky and hard bottom. The State in the last three years planted 48,689 barrels of seed oysters and 1748 barrels of shells on this tonging bottom. Five drags of the dredge at 10 minutes per drag netted about 1/2 barrel of bottom material most of which was mud-blackened shell and boxes. In the material were several clusters of small oysters on which were attached some 1947 set. The setting rate was high on the small amount of cultch available. No market oysters were found.

The mortality represented in the material caught in the dredge was about 95 percent of the total oyster population. Unless this bottom is stiffened or the mud dissipated by wave action until the stiff bottom is again exposed, it would be useless to plant seed or shells. That the bottom may again become usable in areas like this has been demonstrated in other places along this coast. The action of the shrimp trawls and the wave agitation has already accomplished this on some of the oyster bottoms in the area behind Deer Island. Considerable grass and other debris were on the bottom.

Fouling organisms and predators were surprisingly meager. Neither conchs nor drilled oysters were found. Boring clams and sponge were scarce. Polydora was absent. Bryozoa were present but in no great amount.

Oyster meats were good, with considerable glycogen accumulated. Only a small amount of spawn remained in the gonads. Crystalline style was present in each of the oysters opened.

g. Waveland-Clermont Tonging Grounds. Station 16 is on a westerly continuation of the Bay St. Louis tonging area where the bottom is similar to that found at Station 15. All other conditions are likewise the same. Three drags of 10 minutes each were made in this area, and the total catch was 1/3 barrel of bottom material. In this general area the State planted 2060 barrels of seed oysters and 1616 barrels of shells during the last three years. This bottom is mudded and temporarily unfit for use.

II. Tonging reefs and plantings east of Biloxi to the Mississippi-Alabama State Line.

a. Biloxi Bay north of Deer Island. Stations 1 and 2 are near the eastern end of the Island on bottom composed of broken or mixed hard reef, sticky mud and soft mud sloughs. The State in the past three years planted 43,010 barrels of seed and 2019 barrels of

shells in this area. There were three drags of 10 minutes each made south of the dug channel and one drag of the same duration north of the channel. Approximately 3 barrels of material were dredged, most of which were the boxes of recently killed oysters. Large oysters comprised more than 75 percent of the mortality. A few of the small boxes were perforated by conchs. Some marketable oysters were present, also a considerable quantity of small oysters. On the shells and the recent boxes was a heavy set of spat apparently caught since the time of the hurricane, since some of them had to be identified through a magnifying glass. An estimate of the marketable yield from this area by the Chief Inspector was about one gallon per day per man. This amount compared with the usual yield of 8 - 12 gallons per man from the area is indicative of the limited production expected from the particular reef this season. The small oysters present will not be available for harvesting for several years. Most of the live oysters were south of the channel while greater mortality, however, occurred north of the channel.

Fouling was not excessive on the shells and oysters in this area. Small conchs were abundant and actively attacking the small oysters and spat. No evidence of drilling could be found among the larger oysters or boxes. Polydora was present but not abundant.

Oyster meats were fairly good and beginning to "fatten". Some sex products were present in many oysters. Active feeding was indicated by the presence of food in the stomachs and of the crystalline style.

b. Ott's Reef off the old Coast Guard Station. Station 8 is located at the western end of Biloxi Bay at the mouth of Back Bay and south of the railroad bridge. The State recently planted 17,386 barrels of seed oysters in the general vicinity of the western end of Deer Island, and 1000 barrels of shells. In the immediate area of Ott's Reef 5026 barrels were planted in 1944 which were ready for marketing this season. In 7 drags of 5 minutes each at this location, 3 barrels of bottom material were caught, most of this on the offshore portion. Where the bottom was hard reef the inshore half of the reef was covered with soft mud, and most of the recent boxes and mud-blackened shells came from this part of the reef. The majority of the living oysters were small with some 1947 set attached. Many of the small oysters should be ready to harvest next season. Large oysters were scarce.

The fouling was light, mostly Bryozoa. Boring clams were present in moderate numbers in the shells and oysters. Polydora was fairly abundant. Neither conchs nor drilled oysters were found.

The oyster meats were fairly good; the gonads still contained spawn; and the crystalline style was present in most of the oysters.

c. Ocean Springs Tonging Grounds. Station 5 is located east of the main channel entering Back Bay and just south of the town of Ocean Springs. The bottom at this time was mostly soft mud, 8 - 14 inches below which the oyster reef could be felt with the sounding pole. During the past three years the State planted 43,997 barrels of seed oysters and 3500 barrels of shells in this area. Five drags of 5 minutes each comprised the sample catch. About 1/2 barrel of bottom material, largely sticks and dead grass, was all that the dredge brought in. A few clusters of small oysters were found alive mixed with a small quantity of mud-blackened shells. This reef is seriously damaged for the present, and unless it is cleaned either by natural erosion or some other means, rehabilitation by replacing the oysters or shells is inadvisable.

No conchs nor drilled oysters were found. Fouling and other organisms were scarce.

d. Creasus Reef. Station 6 is located north of the railroad bridge on the south shore of Back Bay in 5 feet of water on a bottom of mixed sticky and hard reef. The State planted 31,095 barrels of seed oysters and 3500 barrels of shells during the past three years in Back Bay. All of this was not on Creasus reef which did, however, receive a large portion of it. Three drags of 5 minutes each collected about 3 barrels of bottom material, mostly small oysters, upon which were many 1947 set. About 10 percent of the living oysters were of marketable size. Very few recent boxes were found, and most of these were of large oysters.

No conchs were present in the samples and no evidence of drilling was found. Fouling was light except for a small amount of Bryozoa. Polydora was moderately abundant.

Oyster meats were poor and watery. Gonads still had considerable amounts of mature sex products. The crystalline style was present in most of the oysters opened.

e. Plummer Reef. Station 7 is located north of the railroad bridge on the north side of Back Bay in 5 feet of water where the bottom was hard and sticky reef on the inshore portion and now covered with soft mud and debris on the outer portion. This reef also received part of the large State plantings of seed and shells during the last three years. Three drags of the dredge at 5 minutes per drag collected about 2/3 of a barrel of bottom material. Two of the drags caught a few recent market-size boxes and a little debris. Most of the material in the sample came from the remaining

drag on the inside southeastern edge. On this latter portion of the reef were small live oysters some of which had 1947 set attached. Very few recently killed oysters were in this group.

Neither conchs nor drilled oysters were found. Fouling was light, and the boring clam occurred only rarely.

Oyster meats were fair with very little glycogen present. Gonads were still showing considerable ripe sex products. Crystalline styles were absent in half the oysters examined.

f. Ramsey Point Natural Reef. Station 3 is located off Ramsey Point on the north side of the east entrance of Biloxi Bay in 5 feet of water on bottom that was mostly hard sand with occasional patches of sticky mud. The State planted 10,800 barrels of seed oysters in this area during the last two years. Three drags of 5 minutes each were made at this station, catching a total of 2/3 of a barrel of bottom material. About 1/2 of this catch was oysters, shells and boxes, with debris constituting the remainder. The majority of the recent boxes were market size. There were no live marketable oysters in the sample but a few clusters of small oysters were found. On the inner surfaces of some of the boxes were small 1947 spat undoubtedly caught since the hurricane.

Oyster meats were good with a considerable accumulation of glycogen. Gonads of some oysters still had small amounts of spawn, but some others had expended all the mature sex products. The crystalline style was present in all the oysters examined.

No conchs were in the samples, and no drilled oysters. A few boring clams had lodged in the shells and oysters. Polydora was present but not abundant.

g. Ramsey Point Shell Planting. Station 38 is located on the eastern portion of the natural reef in 6 feet of water on bottom of sticky reef mixed with shell-cinder and sand. The State planted 21,000 barrels of shells from canning factories in this area in 1947, together with a small quantity of oysters for spawning purposes. Three drags of 4 minutes each were made on this shell planting. The dredges came aboard filled with the shells which were covered with small oysters set in 1947. A few of the large spawners which were scattered over the planting were caught in the samples. The set that attached had grown well and already exceeded an inch in length. The area did not appear to be seriously damaged although the Chief Inspector stated that the shell was not as thickly grouped as he had planted it. The oysters should reach marketable size in less than three years at the present rate of growth.

Conchs in considerable numbers and some drilled spat were found. The number of oysters killed by the conch was not very great and, according to the statements of the men well acquainted with the area, the fresh water usually flowing into this region during the spring months would kill most of the conchs without injuring the oysters. A few boring clams were found in the shells of the older oysters. A limited number of Polydora was present.

Oyster meats were fairly good with a considerable amount of glycogen already deposited. Most of the spawn was expended from the gonads. The crystalline style was present in all the oysters examined.

h. Pascagoula Tonging Area near Bayou Graveline. Station 33 is located off Bayou Graveline along the western edge of the prescribed tonging reef in 5 feet of water on bottom of mixed hard and sticky reef. The State planted 2076 barrels of seed oysters from the cooner reef of Pascagoula and 591 barrels of shells in this area during the past three years. Seven drags of 5 minutes each collected a total sample of about 4 barrels of bottom material although two of the drifts made on the western edge of the area had very little in them. The catch contained mostly small oysters and 1947 spat with few oysters of marketable size. Some mortality, confined mostly to the larger oysters, was evident. Much debris of sticks and dead grass was caught in several of the drags.

One small conch was found, but there were no signs of drilled oysters. A large amount of live algae, (colloquially, "grass") both green and red, was attached to the shells and oysters. Other fouling was light. Polydora was scarce in the oysters opened for examination. Very few boring clams were found in the shells and oysters.

Meats were thin and watery; gonads still contained some spawn; and the crystalline style was present in most of the oysters opened.

i. Pascagoula Tonging Area off the mouth of West River. Station 34 is located east of Station 33, in 3 - 4 feet of water, along the edge of the cooner reefs. The bottom was mostly hard reef, but the oysters occurred in lumps separated by patches of sand and mud sloughs. In 1946 the State planted 6760 barrels of seed oysters from the cooner reefs to supplement the natural supply. Two drags of 5 minutes each netted about 1/3 of a barrel of material. There were no live market oysters, and most of the recent boxes were of this size. Small live oysters comprised most of the catch and a heavy setting of 1947 spat attached to the live oysters and boxes. Grass and other debris were on the bottom.

Neither conchs nor drilled oysters were seen. A light fouling of Bryozoa was on the shells and oysters. No boring clams were found.

j. Cooner Reef off the mouth of Middle River. Station 35 is on the part of the Pascagoula cooner reef which supplies the State of Mississippi with most of its seed oysters for transplanting. The seed beds are extensive but in shallow water where our deep draft boat had difficulty in dredging samples. Repeated sounding with the pole showed the bottom to be hard reef covered with clusters of oysters. Five drags of the dredge at 3 minutes for each drag caught about 1½ barrels of bottom material, exclusively small oysters with many 1947 spat attached. A thick cover of a transparent filamentous algae fastened to the bottom interfered to some extent with sampling. The Chief Inspector claimed this "grass" disappeared when the cold weather arrived.

The mortality was light for such a dense bunching of oysters. No conchs were found and no drilled oysters were seen. Bryozoa in small quantity was on the shells and oysters.

k. Middle of the Pascagoula Cooner Reef. Station 37 is located off the mouth of Lac La Buche in 4 feet of water on hard shell reef solid with oysters. Three drags of 4 minutes each were made although more would have been made if the boat had not gone aground wherever sampling was tried. Where samples could be taken the dredge came in completely filled with small oysters that had a considerable amount of 1947 spat attached. No market oysters were found. Mortality was insignificant in spite of the density of the growth.

There were no conchs and no sign of drilled oysters in this area. The oysters were covered with a green organic film, somewhat slimy, but this did not seem to seriously interfere with the catching of the set. No other fouling was evident. Polydora was abundant on the shells of those oysters opened. No algae similar to that found in such abundance at some of the other stations in this region was present. The reef was free of debris and grass.

Oyster meats were poor and watery and still contained a large amount of spawn. Only a few of the oysters opened had the crystalline style present and not much food was in the stomachs.

l. Pascagoula Tonging Area. Station 36 is located on the western bank of the ship channel leading into the Pascagoula River in 4 feet of water on the eastern part of the Pascagoula planted grounds, where the bottom was hard sand and shell reef. The State planted 1805 barrels of cooner reef seed in this area in 1946. Fifteen drags of 4 minutes each were made from the Pascagoula River westward. Each time

the dredge came in full of clustered small oysters. Many 1947 spat were attached to the older oysters. Very few market size live oysters were found. A light mortality had occurred but the few boxes present were mostly recently killed large oysters. The oysters are growing entirely too densely on this bottom and thinning will be necessary to permit them to develop.

Many small conchs were in the samples from the eastern portion of this area. A few spat and small oysters were drilled but on the whole damage from this source was very slight. Fouling was light and restricted to the green discoloration already noted at Station 37. A small amount of Bryozoa was present. Polydora was moderately abundant on the shells of the oysters opened.

The condition of the meats was similar to that found in the oysters at Station 37.

Mussels and barnacles were found at all stations east of Biloxi but, except at Station 36, they were few in number. Here mussels were abundant, although the barnacles were still few.

III. Dredging reefs and planted bottoms east of Biloxi.

a. South of Deer Island, Shellplanting in 1947. Station 4. No natural reef was located in this general area but in 1947 a planting of 1650 barrels of steam house shells was made to extend the producing bottom in the Biloxi region. The bottom was hard sand with neither shells nor oysters present at the time of this survey. The dredge was dragged 4 different times over this planting and each time, except for a small amount of debris, came up empty. This bottom had apparently been covered with sand since the State made its planting. The bottom originally was sticky mud which could be felt under the sand by the sounding pole.

A search was made for the missing shells when they could not be located at the original site of the planting. The shells could not be located but, as the probing moved offshore, a considerable amount of good semi-stiff bottom, suitable for shell or seed planting, was found between the inshore sand strip and the soft mud that appeared outside the stiff mud. The usable strip of bottom was quite wide and extended several miles parallel to the shoreline of Deer Island. The depth of water was from 6 - 12 feet, deepening as the bottom sloped gently away from the shore.

IV. Dredging reefs offshore and west of Biloxi to the Louisiana State Line.

a. Buoy Reef. Station 32 is located about two miles northwest of West Point, Cat Island, on Cat Island Shoal in water 4 - 12 feet deep. The bottom was mostly hard shell reef with sloughs of stiff mud in a few places near the deep water. The dredge was dragged in 4 different places for 4 minutes at each drag. About four barrels of bottom material was brought on deck. Most of this was old shell with only a few large and small living oysters present. The shell, in spite of its age, was clean and contained a fairly large setting of 1947 spat, many of which, however, were killed by the conch.

The dredged material was examined for the presence of conchs, and ten of these snails, ranging in size from 1 to 3 inches in length, were found and one of these was drilling spat when it was recovered from the deck-load of shell and debris. Several other conchs were firmly attached to the "bills" of large oysters.

There were only a few recently killed adult oysters, most of which were drilled. It was estimated that the total mortality, exclusive of dead spat, amounted to about 5 percent in the samples. This mortality was relatively insignificant, but the fact that the conchs were numerous and active indicated a potentially dangerous locality for oysters.

Fouling on shells and oysters was light and consisted mostly of barnacles and mussels. In the dredged material were many crabs, blue, mud, and hermit.

Meats were fair and contained limited amounts of glycogen. Gonads still showed the presence of mature sex products. The crystalline style was present in all oysters examined.

b. George Smith Reed. Station 24 is located two miles northwest of Buoy Reef and one mile east of Square Handkerchief in 6 - 10 feet of water on bottom of hard shell reef. The dredge was dragged in 4 different places for 6 minutes at each drag. The catch in the 4 drags amounted to 3.1 barrels of bottom material, 75 percent of which was small living oysters. The total amount of marketable size oysters was only about 1/6 of a barrel. Shells were old and clean but quite scarce. A recent light setting on these shells averaged about two spat per shell. A few mud-blackened shells were found on the north side of the reef.

The few boxes seen in the samples indicated a low rate of mortality, probably less than 5 percent. Several small oysters, however,

were killed by drills. The conch was present in the samples but not in any great number. Mussels and barnacles were on the shells although fouling in general was not significant.

c. Fletcher Keys Reef. Station 31 is located about 4 miles west of Cat Island on the south side of Pass Marianne in 7 - 13 feet of water on hard shell bottom. The dredged samples were taken at 5 different places and each drag was for 4 minutes. The total catch in the 5 drags was 5 barrels of bottom material. About 50 percent of the catch represented live oysters mostly small and in small clusters. Large or marketable oysters were scarce and scattered in the samples. Very few 1947 spat were present on the shells. The shell was abundant, but old and partly fouled with silt and organisms.

Very few recently killed oysters were found and most of those were small with a total dead not exceeding 3 percent of the population.

Conchs were present although no drilled oysters or boxes were observed. The conchs were small as has been the case on most of the reefs examined. Mussels, barnacles, boring clams and Bryozoa were the major fouling organisms.

Meats were only fair in quality. Gonads still contained ripe sex products which may account for the condition of the meats. In most instances meats do not "fatten" or accumulate glycogen until spawning is over.

d. Pass Marianne Light Reef, also called Lighthouse Shoal. Station 25 is located north of Pass Marianne Light and on the north side of Pass Marianne in 6 - 8 feet of water on hard sand and shell reef. This reef is part of the tail of Square Handkerchief. The samples were collected from 7 different places by dredge with the average length of the drag 5 minutes. About 7 barrels of bottom material were brought on deck for examination of which 60 percent was oysters. Most of this represented small oysters in clusters. Very few marketable oysters were present. There was a comparatively good set of 1947 oysters at the rate of 2 spat per shell. Cultch was old and quite clean except for the attachment of some mussels and barnacles on the shells.

Recent mortality, judged by the clean boxes present, amounted to approximately 8 percent of the oyster population. No conchs were caught and no drilled oysters appeared during the examination.

e. Hornet Reef. Station 10 is located off the southwest end of Pass Christian Tonging Reef in 6 - 14 feet of water with the shallower portion on the inshore side. The bottom was mixed mud, sand and hard reef. The mud covered the outside and eastern portion and apparently had been washed over the original hard reef. Mud-blackened and dead small oysters were dredged from this latter part of the reef. The dredge was dragged 20 times with an average of 3 minutes per drag. About 14 barrels of bottom material was brought on deck. The majority of the material consisted of small oysters and a few large or marketable size. Setting was not abundant although some had occurred since the hurricane. Shells were scarce and scattered over the reef.

Recent mortality, about 10 percent of the population, was confined to the small mud-killed oysters and most of these were in the samples dredged from the outer and eastern part of the reef. No conchs appeared and no evidence of drilling was seen.

The meats were poor. A few oysters had well filled gonads but most of them had spawned out. The crystalline style was present in the majority of those opened.

f. Southeast Part of Square Handkerchief Reef. Station 22 is located about one mile southwest of Hornet Reef in 4 - 8 feet of water, on hard sand and shell reef. The dredge was dragged in 3 different places for an average of 5 minutes per drag. The bottom material dredged amounted to about 1/2 barrel of shells and oysters. In the entire sample only 4 market and a few clusters of small oysters were found. The balance was old shell that contained a scattered set of 1947 spat. No recent boxes were caught.

Oysters were opened for an examination of meats. Their general condition was good although most of the gonads still had spawn. The crystalline style was present. A few Polydora mud vesicles fouled the shells.

g. Western Portion of Square Handkerchief Reef. Station 18 is located offshore of the mouth of St. Louis Bay in 6 - 12 feet of water on bottom mostly hard sand mixed with old shell. The dredge was dragged in 4 different places for 6 minutes at each drag. The total amount of bottom material collected was 0.7 barrels. About 50 percent of this consisted of an equal amount of large and small oysters. The marketable large oysters were long and thin. The set of 1947 was relatively limited. The bulk of material brought on deck came from the north and east portion of the reef. On the western part 2 drags of the dredge were made but nothing was found on the bottom.

Approximately 7 percent of the oysters had died recently. Both large and small oysters were represented among the boxes. Neither conchs nor drilled oysters were in the samples so the mortality could not be attributed to the activity of this predator.

Meats of the oysters were fair with very little accumulated glycogen. Gonads still contained some unexpended spawn. The presence of the crystalline style indicated oysters were feeding.

h. Dredging Reef outside Henderson Point. Station 12 is located between Henderson Point and the northwestern part of Square Handkerchief in 12- 16 feet of water on hard shell oyster reef. The dredge was dragged at 10 different places for 3 minutes per drag. Slightly less than 7 barrels of bottom material were caught in the sampling. Most of this was oysters of various sizes, but predominantly small. Recent 1947 set was present on the shells.

Clusters of recently killed small oysters, blackened by the mud, represented a mortality of about 10 percent of the oyster population. Conchs and drilled oysters were absent.

Meats were fair with very little glycogen deposited. Gonad material was found in most of the oysters examined. The crystalline style was present.

i. Reef North of Pass Marianne Channel. Station 28 is located west of Pass Marianne Lighthouse and parallel to the north edge of the Pass Marianne Channel in 7 - 14 feet of water on hard shell reef. The dredge was dragged in 12 different places with each drag of 5 minutes duration. The dredge, each time it was hoisted on deck, was filled with bottom material, 90 percent of which was small live oysters. A limited number of these oysters had just reached the minimum market size of three inches. Spat of 1947 averaged about 900 to the barrel of shells and oysters.

A few recently killed small oysters were in each dredge load with no apparent cause for the mortality. The total mortality was less than 5 percent of the oyster population. No conchs were found nor were any of the oysters drilled. Fouling was light and consisted mostly of barnacles and mussels. Among the other organisms in the samples were the blue crabs (Callinectes sapidus) in abundance, the stone crab (Menippes sp.) and many mud crabs (Panopeus herbstii).

Oyster meats were good although some spawn still remained in the gonads. The crystalline style was present. No Polydora were found in these oysters. Growth of the shells was good and it is likely that the marketable fraction of this population will increase

during the 1947-48 oyster season. The oyster thus developed will be too small for raw trade, but in canning, this size is often the bulk of the processed material.

j. Calico Reef. Station 14 is located 1 and 1/2 miles offshore and west of Bay St. Louis in 8 - 12 feet of water. The State planted shell in this area in 1947 to maintain the reef. The dredge was dragged in 4 different places for 5 minutes per drag, and the total haul was 4 barrels of bottom material. Most of this was small oysters with market size and 1947 spat scarce. Few blank shells were found.

Mortality, confined to small oysters, was light, averaging 8 to 10 percent of the population. No conchs were found and no oysters were drilled. Fouling consisted of mussels, barnacles, Bryozoa and boring clams in limited numbers.

Meats of the oysters were fair and slightly watery. Gonads contained considerable sex material. The crystalline style was present in all oysters. Polydora was found in the shells.

k. Bayou Caddy. Station 17 is located off Point Clear at the mouth of Bayou Caddy in 4 - 8 feet of water on bottom composed of stiff mud and sand. Since 1945 the State planted both seed and shell in this area. The dredge was dragged in 3 different places on the plantings for 10 minutes at each drag collecting about 1/6 of a barrel of bottom material. There were 15 small oysters and one market size in the sample. A good set of 1947 spat had caught recently on the cultch present. A large portion of the sample was dead grass, twigs and branches of trees and shrubs apparently deposited during the recent hurricane. The scarcity of oysters and cultch in spite of the fact that the State had made substantial plantings, could be accounted for by the windrows of bottom material deposited on the adjoining shore. There is no doubt that the hurricane damaged this planted area almost to the extent of complete destruction.

Mortality of oysters occurred, but to determine the amount from this examination was difficult because dead oysters and boxes were not found on the reef, although they were in the debris washed up on the adjacent beach. Conchs and drilled oysters were absent.

The meats of the few oysters examined were fair. Gonads still contained spawn. The crystalline style was present indicating some feeding.

l. East St. Joe Beacon. Station 21 is located in the channel of the easterly extension of Grand Island Pass in 12 - 15 feet of water

on bottom of semi-stiff mud and shell gravel. The dredge was dragged in 4 different places for an average of 5 minutes per drag. The total material caught amounted to about 2.8 barrels. Oysters, all small, were scarce. On the shell gravel was a fairly heavy set of early and recent 1947 spat.

Mortality was light and amounted to 3 to 4 percent of the oyster population. Neither conchs nor drilled oysters were found. Shells were badly fouled with Bryozoa. There were also a few barnacles and mussels on the shells and oysters.

m. Natural Reef on the eastern side of Heron Bay. Station 20 is located close to shore near the site of the abandoned lighthouse on Little Point Clear in 6 - 30 feet of water. The bottom was mostly hard shell gravel except on the inshore portion where large masses of decomposing grass and mud covered the original hard reef. The dredge was dragged in 3 different places for 6 minutes at each drag in which about 1 barrel of bottom material was collected. Live oysters of all ages, including 1947 spat attached to the shell-cultch and oysters, were scarce.

The observed mortality was distributed indiscriminately among all ages of oysters. The boxes were mud-blackened and gave every indication of being smothered by the recent influx of grass, debris and mud washed in by the hurricane. The total mortality was approximately 20 percent of the population remaining on the reef. Here again the shore was covered with a windrow of dead oysters and shells deposited recently, indicating a severe loss of oysters and bottom cultch from this reef.

Neither conchs nor drilled oysters were in the samples nor in the debris and shells washed ashore. Mussels and barnacles were present in small numbers. Shells were relatively clean and good for cultch although the amount was scarce.

n. Heron Bay, West Shore Natural Reef. Station 19 is located at the entrance of the Bay in 6 - 9 feet of water. The bottom was stiff clay mud, sand and shell reef, with the inshore portion of hard bottom covered with a layer of dead grass, debris and mud. The dredge was dragged in 6 different places at 8 minutes per drag. About 1 barrel of bottom material was caught with only 10 percent of it living oysters, mostly small. A light setting of 1947 spat was attached to the loose shell and oysters still remaining on the reef. Sampling showed more oysters and shells on the offshore portion of the reef than on the inshore part.

About 15 percent of the population on the reef was killed. The recent mortality was demonstrated by the mud-blackened condition of the outside of the boxes. An unknown number of oysters was killed by being beached during the storm. Hurricane damage was severe, both with regard to oyster mortality and the destruction of parts of the bottom.

Neither conchs nor drilled oysters were found. Mussels, barnacles and clams were among the associating organisms in this area. Fouling in general was light and the shell-cultch was clean.

o. Western end of Cat Island Channel North of Pistol Banks. Station 26 is located on the Mississippi-Louisiana line in 21 feet of water on hard shell reef containing many oysters. The dredge was dragged in 3 different places for 5 minutes per drag and came in fully loaded at each haul. Most of the material was old, eroded shell, recent boxes and a few living oysters.

Large oysters, recently killed, constituted about 60 percent of the population. It was difficult to explain the heavy mortality except to say that the oysters had not been smothered in mud. Large conchs were numerous and may have been partially responsible for killing some oysters. The evidence of drilling was found among the smaller boxes and several drills were still boring the oysters at the time the samples on deck were being examined. Pinna and the hard clam Venus were found, as well as mussels, barnacles, Crepidula and calcareous tube worms (Annelids). Most of the shells were old and fouled.

The meats of these oysters were fair. Gonads were empty. The crystalline style was present in all the oysters opened.

p. Pelican Keys. Station 27 is located north of South Pass on the Mississippi-Louisiana line in 3 - 9 feet of water. The keys are shell banks often exposed at low water. The bottom was hard shell reef composed of old shell and shell fragments. The area was small and only one drag of 10 minutes which caught 0.7 of a barrel of bottom material, mostly old shell, a few large and small single oysters and a few 1947 spat was made. The Keys were heavily worked by the dredgers for canning grade oysters during the 1946-47 season. This location did not appear to have been harmed by the hurricane and the scarcity of oysters was no doubt the result of intensive oystering during the previous year.

Recent mortality, about 5 percent of the population, was light. Small conchs were present but no evidence of drilled oysters appeared in the sample.

q. Umbrella Key Reef. Station 30 is located 1 and 1/2 miles south of Pass Marianne Light on the edge of the deep water north of Cat Island in 8 - 13 feet of water on hard shell reef densely populated with oysters. The dredge was dragged in two different places for 3 minutes per drag, and came in filled with oysters. The total dredged sample amounted to 2.7 barrels of bottom material, mostly clustered small oysters. Both market size oysters and 1947 spat were scarce. Shells were scarce and clean.

Mortality was extremely light, less than 3 percent of the population, as indicated by the few boxes recovered. Neither conchs nor drilled oysters were found.

Meats were in fair condition with very little accumulated glycogen showing at this time. Gonads contained some unexpended ripe sex products. Polydora was absent from the shells of the oysters opened.

r. Telegraph Key. Station 29 is located one mile west of Umbrella Key in 4 - 8 feet of water on hard shell reef. The dredge made 12 drags for 4 minutes at each drag. Each dredge-haul loaded the dredge and approximately 12 barrels of bottom material were brought on board. Oysters comprised 90 - 95 percent of the samples. Most of the oysters were small and clustered; only a few had reached marketable size. Setting was not abundant. A few old, eroded, but clean shells were scattered in the sample.

Mortality was negligible, not exceeding 3 percent of the population. Neither conchs nor drilled oysters were found. Mussels, barnacles, blue crabs, rayfish and blowfish were some of the associating organisms caught in the dredge.

Oyster meats were fair with very little glycogen accumulated in the tissues. Gonads still contained some mature sex products. No Polydora mud vesicles were found in the shells of the oysters opened.

Summary

When the examination of the major oyster producing bottoms of Mississippi was completed, it was possible to qualitatively evaluate the damage inflicted by the hurricane of September 19, 1947, in terms of reduced oyster production, loss of income to the industry in general and to the individual oyster fisherman and packing house worker, and finally, loss in tax revenue which the State could have used in a rehabilitation program of recovery.

The damaged area extended from Ramsey Point, just east of Biloxi, westward to the Mississippi-Louisiana line. The most severely affected portion was the inshore oyster beds from Bay St. Louis west to the State line. Most of the tonging reefs and planted bottom in this region were destroyed. Oysters reported to have been present were either killed or had disappeared. State plantings of seed and shells, which cost $30,000, made to supplement the natural population of oysters in this section, suffered severely. The natural reefs that had been able to support many tongers, even without the addition of the State plantings, were also lost or seriously damaged. Some of the reefs, fortunately, are immediately reclaimable but other parts where mud was washed a foot or more deep over the reef probably will take years to recover. Several packing houses on this part of the coast usually were kept busy by the oysters supplied in large part from this area. The houses are being repaired and reopened but the supply of oysters to keep them operating will not be available at least for the season of 1947-48.

The variability of the effects of this particular hurricane is shown by the conditions found as the survey moved eastward. The oyster reefs in the immediate vicinity of Pass Christian were damaged, but not entirely destroyed. Recently killed oysters of all sizes were represented among the mud-blackened boxes. No large oysters were available from the reefs at this time but many small ones were still there. This does not alleviate the present condition, but leaves some hope for a production of oysters within the next year or two. The oyster population on the reefs a short distance eastward of Pass Christian to Long Beach were almost entirely lost or killed, although the shell bottoms were not destroyed. This loss included some extensive seed and shell plantings recently made by the State. Again, the loss to the State in the cost of these plantings, which amounted to about $4,000, only represented a small part of the real value destroyed, as many natural reefs also existed here. This area furnished many oysters to the above mentioned packing houses processing oysters from the reefs.

No oysters of commercial size were found between Long Beach and Biloxi. In the Biloxi area, however, damage was sustained by both the oyster reefs and plantings. Here is the center of the Mississippi oyster industry and many houses, at least fifteen, depended to a large extent on the inshore reefs in Back Bay and Biloxi Bay between Deer Island and the mainland for raw trade oysters. The cost of seed and shell plantings, and also the losses to the State in the destruction or damage to the planted bottoms involved in the operational cost, amounted to about $55,000. Peculiar to this area as well as to some reefs farther east, a heavy mortality occurred among the large or marketable oysters. An official estimate by the Chief Seafoods Inspector of Mississippi of the yield from the tonging beds in

the Biloxi area this year would be one gallon per day per man as against the usual yield of eight gallons per day per man.

In all, the State lost the initial value of its plantings in the very conservative amount of $75,000 to $100,000. In addition, it has lost the revenue in taxes on the yield from these plantings which would amount to approximately $10,000. There is no way to estimate the loss in revenue that will be sustained by the destruction and damage to the oysters that would have been caught on the natural reefs and subject to the tax. It would probably be at least as much as would be realized from the cultivated reefs.

Strangely enough, the offshore dredging areas suffered much less than the coastal tonging regions, but here again this situation offered no relief because the offshore oysters were mostly small and not ready to harvest due partly to the mortality of the major portion of the population in 1945 by the fresh water from the Bonnet Carre Spillway.

The seed beds in the vicinity of Pascagoula were not noticeably affected by the hurricane except for the loss of the larger oysters. The tremendous quantity of small oysters still alive offered, as seed, some ray of hope to the State as an aid in the rehabilitation that will be necessary to make Mississippi oyster reefs produce again.

Mississippi is one of the major oyster canning States in the country. Biloxi is the center of this industry. The residents of the city depend almost entirely on this industry for their livelihood. There are about 8,000 to 10,500 persons working in the oyster and shrimp packing industry. Also, there are about 100 boats which employ 400 men to catch the oysters, and 700 small skiffs that keep 1400 men working at the same task. Many of these persons will not be employed from now until the spring unless oysters can be caught and canned. Mississippi simply does not have any oysters to use and the neighboring State of Louisiana, which also suffered some losses in this hurricane, has declared the supply in its waters limited. The prospects for the industry and the workers depending on it do not look bright for this year nor, in all probability, for several years to come.

The reefs damaged and destroyed must be rehabilitated and the sooner the task is begun the sooner production will return. The reefs will undoubtedly come back by themselves if left alone, but it will take many years, and the industry cannot wait nor can the people in the State, whose training fits them for this work, easily find other employment without leaving the area completely.

Rehabilitating the Damaged Reefs

The methods for the rehabilitation of the reefs are known and the materials for a start in this important task are on hand in Mississippi. The program involves transplanting of seed or small oysters to some areas and clean shell to others.

The seed is now growing on the shallow reefs off Pascagoula. There is probably 300,000 barrels of it that could be collected and transplanted. The time for transplanting it is now and until the warm weather starts. There is more risk in moving the seed when the temperature is 80 degrees than when it is 32 degrees. Fall and winter transplanting would not harm the oyster which lives in the fairly high salt water of Pascagoula. Moving seed as soon as the operation could be started this year would have another advantage. It would furnish employment to many of the boatmen and oystermen whose income for the next few months will be lean. The State authorities, responsible for this work in the past, have estimated it would cost 50 cents a barrel to catch and transplant the oysters. Moving 300,000 barrels of seed would, therefore, cost about $150,000. The area that this seed could rehabilitate would be approximately 1,000 acres if it is planted at the rate of 300 barrels to the acre. This would be a fairly heavy planting and if the rate per acre were reduced to one-half of that amount 2,000 acres would be well covered at 150 barrels per acre. Better and faster growing oysters would result from the latter concentration and approximately three square miles could be planted. There is ample oyster bottom all along the coast from Biloxi to Waveland that could be used. It is hardly necessary to indicate the exact spots for this operation because the members of the Mississippi Seafoods Commission, with advice from its field staff, could select the bottoms that would support the plantings. All three Gulf coast counties need some help and each has suitable bottom for this development.

The second part of a rehabilitation program for the Mississippi reefs is shell planting. This operation usually involves a more thorough knowledge of conditions than is necessary when planting seed. In the first place, the setting potential of the area must be known in order that spat may be caught; and second, it must be realized that a supply of adult oysters is available to furnish the spawn. From observations made during the course of this survey, the problem of adequate spawn in the water does not seem to be a serious one. On almost all reefs studied, even those very seriously damaged, it was noticed that oyster set had attached to the single shells and boxes. This was very apparent in the Deer Island section where fresh spat were found within the boxes of the recently killed market size oysters. Some spat were so small they had to be identified through

a magnifying glass, indicating oysters were setting as late as early November. In Biloxi at least 500,000 barrels of shells were piled outside several oyster packing houses. The shells were not public property but undoubtedly could be bought at a reasonable figure for a shell planting program. The State has been able to purchase and transplant shell at 46 cents a barrel and possibly could do so with these shells. Allowing 4 cents for additional overhead expenses and using 50 cents as a cost unit, it would take $250,000 to purchase and plant these shells. To establish a shell planting for building a substantial tonging reef, the shells should be planted heavier than seed. At the rate of 500 barrels to the acre it would be possible to establish 1,000 acres of shell planting or about 1 and 1/3 square miles. Again, the shell-planted area may be increased by reducing the amount of shells planted per acre. The minimum planting should not be less than 250 barrels of shell per acre.

The two programs could be integrated to take care of the need for spawners in the vicinity of the shell planting, by placing some of the seed adjacent to the shells. Mixing the shell and seed on the same bed should be avoided as it would work a hardship on the tonger by forcing him to cull the mixed material on deck to get the oysters.

The proper time for shell planting is important and must be considered. Oysters do not spawn all the time but go through a period of some months, usually in this climate from December to April, when gonads are dormant and no spawn is produced. Sometime late in April or early May gonads are again producing spawn and discharging it into the water. Shells may be put into the water with a better chance of catching a set if the operation is started late in May and continued through September. If shells are planted during the other months, from October through April, they become fouled by organisms that reduce the efficiency for catching set proportionately to the extent of fouling.

Under the program as outlined above the important tonging areas from Biloxi to Waveland may be made productive in two years and with occasional shell and seed planting may become self-sustaining. On some of the tonging reefs at Pass Christian, Biloxi and Back Bay, and outside the cooner reefs at Pascagoula oysters are too small for this season's use, but they will be marketable in 1948-9. This will permit a limited production but it may be the last for some time to come unless an effort is made immediately, through planting operations, to rebuild a supply for two and three years hence.

With the aid of man, coupled with the natural assets of the Mississippi oyster, prolific spawning, good setting and rapid growth, there is no reason to doubt that time will produce a complete recovery of oyster production from the reefs of Mississippi.

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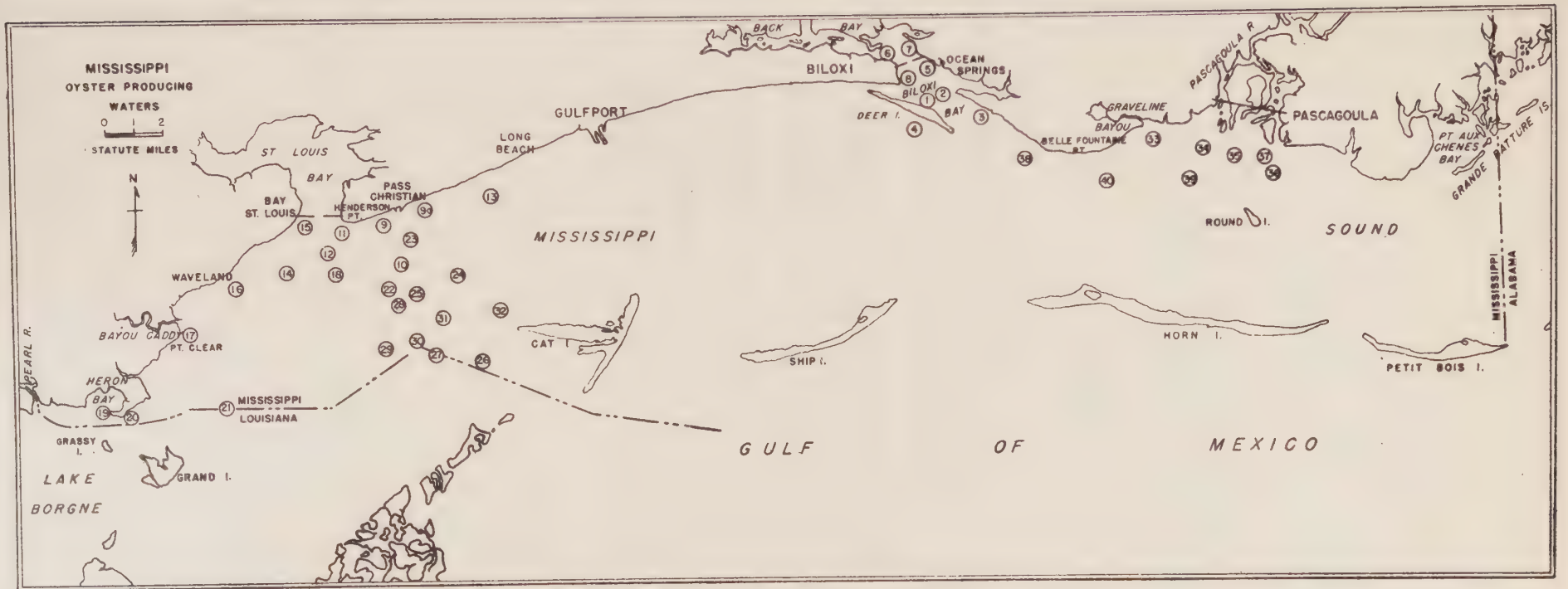

Figure 1. Locations of sampling stations in Mississippi oyster producing waters, established for a survey of the extent of hurricane damage, 1947.

II. A Report of the Investigation of the Oyster Reefs of the State of Louisiana following the hurricane of September 19, 1947.

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Introduction

A request was made by Commissioner L. S. Montgomery of the Louisiana Department of Wildlife and Fisheries, addressed to the Director of the U. S. Fish and Wildlife Service, for an examination of the oyster bottoms in Louisiana, lying within the path of the hurricane of September 19, 1947. In view of the severity of the storm it was felt by Louisiana conservation authorities that damage was inflicted to the reefs and oysters, and a knowledge of the extent of this damage was necessary. This examination was made following the completion of similar studies in Mississippi and Alabama. The investigation started December 8 and continued through December 13, 1947.

The hurricane, in a northwestward movement along the Gulf Coast, included in its path of destruction the territory bordering the shores of Chandeleur and Mississippi Sounds, the location of many oyster reefs. Damage was evident on some of the reefs and planted bottoms in this part of Louisiana, locally called the Marshes. There was a lack of any definite geographical pattern in the extent of harm inflicted. Damaged areas were disconnected and interspersed with reefs apparently untouched.

To gain a more comprehensive idea of the area affected by the storm a trip in an amphibious plane was made covering approximately 300 miles. The air reconnaissance started at Brush Island on Chandeleur Sound, traveled south to Quarantine Bay, west to Barataria Bay and northeast across the Marshes to the starting point. Flying at 200 feet gave a sufficiently extensive view of the territory and still permitted close scrutiny of the area. Only in the Marshes was there any evidence of the hurricane's passage over the region and this justified the concentration of the main part of the survey within the limits of the area examined in detail.

Equipment and Methods

The equipment and methods employed in this survey were similar to those just used in Mississippi and Alabama. The same commercial dredge boat, the Uranus, owned and operated by the Mississippi Seafoods Commission and equipped with the standard 42 inch dredge, was used. The Uranus was captained by Mr. Emil De Sylvey. The new patrol vessel of the Louisiana Department of Conservation, the Captain Sandras, accommodated the survey party as a headquarters boat.

Samples of dredged bottom material were quantitative within the limits of the efficiency of the commercial equipment used. The procedure, when dredging samples of bottom material, was as follows: (1) the length of the drag was timed; (2) the volume of the catch was estimated for each drag and the total volume of the material from a sampling area was the total of all drags from the area; (3) the contents of the catch was evaluated to the percentage of live oysters, dead oysters (boxes), shells and debris; and the principal predators and fouling organisms were listed. The apparent causes of the mortality among oysters were discussed.

Some oysters were opened at each station or sampling area to determine the quality of the meats, the presence or absence of the crystalline style, the amount of ripe gonad material available and the condition of the inner surfaces of the shells with regard to the occurrence of the mud blisters or vesicles of Polydora and the perforations made by the boring clam or boring sponge. At some stations tissues of live oysters were examined microscopically for the presence of Nematopsis spores. Dead oysters were only those whose empty shells were still joined by the horny hinge or ligament or those boxes that still had meat attached. The dead oysters and boxes were examined for evidence of drilling by the conchs.

The approximate density of the oyster population was calculated on the basis of the amount in barrels dredged per unit area. The area scraped by the dredge was arrived at by determining the square yards that were dragged per unit time. This size dredge covered 137 square yards per minute when dragged at the rate of 4 miles per hour. Comparing the catch in barrels by this method made it possible to tell the relative distribution of oysters and other bottom material on the oyster reefs and planted bottoms at this time.

Records of shell planting and other cultivation practices were not complete and obtained only by word of mouth from Mr. James N. McConnell, Director, Division of Oysters and Water Bottoms, Louisiana Department of Wildlife and Fisheries, and Mr. De Sylvey. What little available information thus gathered and considered pertinent to this report will be included in the detailed discussion of the conditions on the individual reefs.

The relative stiffness of the reef or planted bottom was determined by sounding with a pole. A member of the survey party was constantly using this check while the sample was being collected. The bottom consistency was classified as follows:

Classification	Symbol[1/]	Description
Hard reef	H. R.	Solid oysters and (or) shells
Sticky reef	St. R.	Oysters and shells on or in stiff mud
Sand	Sd.	Usually without oysters or shells
Sticky mud	St. M.	Stiff mud without oysters or shells
Soft mud	S. M.	Pole penetrates easily - no oysters

With these data it was possible to establish whether or not recent mudding had covered the reef or planting. Often the soft mud, when found, was 8 to 12 inches deep overlaying the shells and oysters of a reef.

Water samples for the determination of salinity and turbidity were collected from the bottom layer. The specific gravity of the water was obtained with standardized hydrometers with the conversion to salinity taken from the tables prepared by Knudsen (1901). Turbidity was qualitatively noted from the amount of suspended matter clouding the collected water sample which was arbitrarily designated as clear, light, moderate or heavy.

Bottom water temperatures were taken at most of the stations with a reversing thermometer reading to 0.2 degrees Centigrade.

The locations of the reefs were known to the boat Captains, Messers. Emil De Sylvey and Anatole Bougeois, and upon them was placed the responsibility of naming the individual sampling area for identification. Mr. McConnell was equally well informed about the positions of the reefs and assisted in locating many of them. No official State maps were available that charted the boundaries of the oyster reefs. The sampling areas therefore were plotted on a Coast and Geodetic coastal chart for future reference. A tracing of this chart showing the station locations is included here as Figure I.

Salinity, Temperature and Turbidity

The waters of Mississippi and Chandeleur Sounds as well as that in their tributaries and lakes in the Louisiana Marsh region had sufficiently high salinity at this time for the existence of oysters. The highest salinity, over 20 °/oo, was recorded at Grand Pass and Creole Gap in the extreme northeastern part of the Louisiana oyster grounds. The former station is in Mississippi Sound and the latter in Chandeleur Sound. The lowest salinities, between 9 and 10 °/oo,

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1/ Symbols used in Table 2.

A Summary of the Dredging and Material Collected in Louisiana.

Station	Depth	Type of Bottom 1/	Number Drags	Time per Drag in Mins.	Area Covered By dredging in Sq.Yards	Total Amount Material Dredged	Amount Material per 5 min. Drag	Conchs	Live Oysters			Recent Oyster Mortality Per cent Dead
									Market	Small	Spat	
I - Mississippi Sound												
1 (a)	8'	H.Sd.	1	6	822	0.0 bbl.	0.00 bbl.	0	0	0	0	0% 2/
2 (b)	9'	H.Sd.	1	5	685	0.3 "	0.30 "	0	0	few	few	5% 2/
3 (c)	6'	Sd.-M.	1	13	1,781	0.3 "	0.09 "	0	0	few	0	0% 2/
4 (d)	8'	H.R.-M.	2	6	1,644	2.0 "	0.82 "	0	0	many	many	10%
5 (e)	7'	St.R.	1	6	822	1.3 "	1.07 "	0	0	many	few	90% 3/
6 (f)	11'	H.R.	1	8	1,096	1.0 "	0.62 "	0	0	many	0	10%
7 (g)	11'	H.R.	2	5	1,370	1.5 "	0.74 "	0	few	many	few	25%
8 (h)	8'	H.R.	3	4	1,644	2.3 "	1.01 "	0	few	many	many	5%
9 (i)	7'	H.R.	1	5	685	0.2 "	0.20 "	present	few	few	few	50% 3/
10 (j)	25'	H.R.-St.	1	6	882	0.7 "	0.58 "	0	many	few	many	25% 3/
II - Chandeleur Sound												
11 (a)	5'	H.Sd.	3	5	2,055	0.1 "	0.02 "	present	scarce	scarce	scarce	25% 2/
12 (b)	4'	H.R.	3	4	1,644	2.3 "	0.71 "	0	many	few	many	5%
13 (c)	7'	H.R.-St.	4	3	1,644	2.0 "	0.82 "	0	0	many	many	5%
13a (d)	7'	St.R.	2	6	1,644	1.0 "	0.41 "	0	0	many	many	5%
14 (e)	15'	H.R.-M.	1	5	685	0.5 "	0.48 "	0	few	0	0	5%
15 (f)	5'	H.R.	3	5	2,055	3.0 "	0.99 "	present	many	few	many	5%
16 (g)	5'	H.R.	4	4	2,192	1.0 "	0.31 "	present	0	few	many	50% 3/
17 (h)	5'	St.R.	1	3	548	0.8 "	1.32 "	0	0	many	many	0%

38-e

1/ See page 38 for classification of bottom.

2/ The mortality recorded was only that listed for the sample examined; the true mortality may be much greater if it were known how many oysters were under the sand.

3/ The mortality was mostly restricted to the 1947 set and small oysters.

occurred at the stations in the northwestern portion of the oyster grounds at the entrance of Lake Borgne near Grassy Island and Three Mile Pass. At all of the other stations the salinity ranged between 16.5 to 19.0 °/oo.

The water temperatures fluctuated between 12 and 18 degrees Centigrade. These changes were the result of the effects of variations in the air temperature which were quickly reflected in the shallow waters of this part of Louisiana.

Silt and other factors affecting the color and clarity of the water were generally in such small amounts that the water might be considered clear. To the eye the water appeared clear but the sample collected in a citrate bottle showed a deposit of light fluffy brownish silt after standing undisturbed for a few days. Only in Eloi Bay near its entrance into Chandeleur Sound was there any evidence of turbid water and here it was not very dense. Silting in this area can be a serious condition at times of freshet on the Mississippi River when its muddy water infiltrates the Gulf of Mexico and the adjoining sounds. Some silting was produced during the recent hurricane. The salinity, temperature and turbidity of the water in this area at the time of the survey are shown in Table 1.

The relative scarcity of conchs in the region would indicate a possible range of salinity which occasionally must be low enough to impose a restriction on the spread of the snail. The distribution and damage from conchs will be discussed when the conditions on the individual reefs are explained in detail.

Description of the Louisiana Oyster Reefs and Planted Bottoms

Most of the week of December 8, 1947, was spent in the field sampling by commercial dredge the principal oyster reefs in the part of the Louisiana waters generally within the path of the hurricane. To cover the area 17 sampling stations were visited, the locations of which are shown in Figure I. From 1 to 4 dredgings were made at each station, ranging from 3 to 13 minutes with an average of about 5 minutes per drag. The total area actually covered in dredging was about 23,898 square yards. For comparison convenience the amount of bottom material caught was adjusted to the amount collected per 5 minute drag. The average amount of material caught per 5 minute drag was 0.77 barrels, ranging from 0.06 to 1.65 barrels. A summary of the results of dredging is shown in Table 2.

A narrative description of the individual station areas is given below for a more comprehensive picture of the conditions on the reefs.

Table 1

Salinities, Temperatures and Turbidity of the marine waters in Louisiana.

Station	Location	Date 1947	Depth in ft.	Salinity °/oo	Temp. °C	Turbidity
	Mississippi Sound	Dec.				
2	Grassy Island	9	9'	9.38	-	clear
5	Three Mile Bayou	9	6-7'	9.61	17.4	light
6	Johnsons Bayou	9	10-12'	18.82	17.0	clear
7	Grand Pass	9	9-12'	20.84	-	light
8	Creole Gap	10	6-8'	21.96	16.8	light
	Chandeleur Sound					
11	Deep Water Pass	10	4-5'	17.28	17.8	clear
12	Karako Bay-East	11	3-4'	16.53	14.0	light
15	Martin Island	10	5'	17.61	18.0	clear
16	Eloi Bay-East	11	5'	16.98	11.8	moderate

The stations are considered in groups arbitrarily arranged by geographical units, namely, those in Mississippi Sound and those in Chandeleur Sound.

I. Mississippi Sound

a. Northwest of Grand Island. Station 1 is located on the southern edge of St. Joe Channel in the extreme western part of Mississippi Sound at the entrance of Lake Borgne in 6 to 8 feet of water. This area is often exposed to the fresh water from Lake Borgne and during this survey the salinity here was the lowest recorded. The bottom was mostly hard sand. The members of the survey party, who were well acquainted with the locality, claimed that this was the site of an extensive natural oyster reef previously containing many oysters. The sounding pole when forced deeply into the sand encountered buried shells or oysters. The presence of shells and oysters was indicated also by the bouncing of the dredge as it dragged over the bottom. Apparently sand had covered the area. The dredge was dragged for 6 minutes during which time the bottom was being constantly sounded with a pole. The dredge came up completely empty. Soundings were made over a wide part of the area and the same sand covering prevailed.

The conditions found on this reef were undoubtedly the result of the hurricane disturbance. The damage inflicted will be long-standing because the sand now covering the original reef will be difficult to remove and planting on sand in this shallow water could not be recommended.

b. East of Grassy Island. Station 2 is located west of Station 1 in 9 feet of water. Practically the same conditions existed on the bottom in this area as at Grand Island which was hard reef covered with sand. The dredge was dragged for 5 minutes and the catch amounted to 0.3 of a barrel of bottom material, mostly old shell with a few small oysters and 1947 set. Sounding with a pole revealed this situation to exist over the whole area.

The apparent mortality of oysters was negligible. On the other hand, the captain of the dredge boat collecting the samples claimed that in early September of this year, during the official pre-season examination of the reef, he was able to fill his dredges with small clustered oysters by making very short drags. The fact that these oysters are practically gone and no harvesting has been done indicated the loss, occurring this fall, was undoubtedly the result of the hurricane disturbance which washed the loose material off the reef and covered the firm shell with sand. Neither conchs nor drilled oysters were present in the sample.

Fouling was heavy on the material collected and consisted of Bryozoa, barnacles, hydroids and mussels. The fact that the fouled material was caught on top of the sand and contained no mud-blackened shells or oysters permits the assumption that this was material washed in from some other place.

The few oysters found in the bottom material were opened for examination. The meats were fairly good in color and firmness. The gonads were filled with spawn. All oysters had the crystalline style present although food was not found in any great amount in the stomachs. The tissues of these oysters were examined for the presence of Nematopsis. Cysts of this parasite were abundant in the mantle.

c. Southwest of Grand Island. Station 3 is located between Grand Island and Le Petit Pass Island in 6 feet of water. The bottom was a mixture of sand and stiff clay mud which was quite hard. The dredge was dragged for 13 minutes and netted a catch of only 0.3 of a barrel of bottom material. Repeated soundings with a pole failed to locate any quantity of shell or oysters. The dredged material contained only a few clusters of small live oysters, some mud-blackened shells and no recent set. The bulk of the material was decomposing grass and grass-root clumps loosely matted together. The presence of this debris points quite conclusively to the fact that the hurricane had disturbed the bottom.

There was no evidence of oyster mortality. Neither conchs nor drilled oysters were found in the sample.

d. North of Le Petit Pass Island. Station 4 is located south of Station 3 and close to Le Petit Pass Island in 7 to 10 feet of water. The bottom was mostly hard reef with scattered lumps of semi-stiff mud. The dredge, dragged in two different places for an average of about 6 minutes per drag, caught approximately 2 barrels of bottom material. Most of this was old planted shell to which was attached a fairly abundant 1947 set. Many clusters of small live oysters, but none of marketable size, were mixed with the shell. The small oysters were growing well and an appreciable number of these would undoubtedly be 3 inches long before next spring.

Very few recently killed oysters were found. Concns were absent and no drilled oysters were seen. Apparently the hurricane had not noticeably affected this immediate area.

Meats were good and "fat" with accumulated glycogen. The gonads had expended most of the ripe sex products. Feeding was active in all oysters as indicated by the food in the stomachs and the presence of

the crystalline style. Polydora mud vesicles were scarce.

Fouling by Bryozoa on the old shells was fairly heavy, and some barnacles and mussels were attached to oysters and shells

e. West of Three Mile Bayou. Station 5 is located in Mississippi Sound just west of the entrance to Three Mile Bayou in 6 to 7 feet of water. The sticky mud bottom received a shell planting in 1947. This extensive area was selected by the Louisiana Department of Conservation for the required planting of 40,000 barrels of shell equal to 10 percent of all the 1946 catch by the Mississippi boats. The shells were broadcast in a heavy layer over the bottom. Dredges came in completely filled, mostly with planted shell which had caught a very abundant 1947 set. Scattered through the shells were clusters of small live oysters of an earlier set. A few market size oysters were in the sample. In all 1.3 barrels of material were examined.

Mortality was confined to the 1947 spat which apparently had died quite recently, because the shells of the individuals were still intact and joined by the horny hinge. The large size of the spat indicated an early setting. The time of the mortality coincided closely with or shortly after the hurricane struck the area. Neither conchs nor drilled oysters were found.

Fouling was very light and consequently the planted shells were still clean.

f. North of Johnsons Bayou. Station 6 is located on a hard shelly reef in Mississippi Sound just outside of Johnsons Bayou in 11 feet of water. This area, where the actual reef is situated like an underwater island in a sea of soft mud, is known as a "humpback reef". The dredge was dragged for 8 minutes and collected about one barrel of bottom material, mostly clusters of 2 inch oysters. Some marsh grass debris was mixed with the shells.

Several clusters of mud-blackened boxes suggested a recent mortality representing less than 10 percent of the oyster population. Conchs were absent and no drilled oysters were found. The presence of the loose and decomposing marsh grass debris and the mud-blackened boxes indicated some slight hurricane damage. On the whole this will not seriously affect the potential production from the reef when the oysters in this population grow large enough to harvest next year.

Meats were only fair. The accumulation of glycogen was still low which left the oysters thin. Spawning appeared to be over with the ripe spawn fully expended. Oysters were feeding and the crystalline style was present. The oyster shells were relatively free of Polydora mud vesicles.

The shells from the natural reef were badly fouled with Bryozoa. A few barnacles were also attached to both oysters and shells.

g. North of Grand Pass. Station 7 is located in Mississippi Sound north of the entrance of Grand Pass in 9 to 12 feet of water on a bottom of hard natural reef. The dredge, when dragged at two different places for 5 minutes at each drag, caught approximately 1½ barrels of bottom material. The catch in the first drag on the inshore portion of the reef contained many large and small oysters in clusters. Very few 1947 spat were found. Some debris, clumps of marsh grass, was in the sample. The second drag was made on the offshore portion of the reef and the dredge came in almost completely filled with small oysters. These oysters, in spite of their small size, did not appear to be young animals. No debris was found in the second drag.

Some recently killed oysters were found. The majority of these were small and in clusters although larger market size oysters in lesser numbers also had died. The mortality represented almost 25 percent of the population. Neither conchs nor drilled oysters were found.

The meats were only fair and still quite thin. The gonads had expended the ripe spawn. Food was found in the stomachs and the crystalline style was present. The oyster tissue was searched for the spores of Nematopsis, a few of which were found scattered in the mantle.

Fouling on the shells and oysters was quite heavy, principally Bryozoa, mussels, and barnacles. The bottom itself was fouled with decomposing marsh grass and clumps of roots and stalks broken from the edges of the nearby marshy islands by the hurricane.

h. Creole Gap Reef. Station 8 is located north of Creole Gap near Cabbage Reef, in 6 to 8 feet of water on hard shell reef. Dredgings were made in three different places with each drag about 4 minutes. A total of 2¼ barrels of bottom material was caught and examined. The catch was mostly oysters in small clusters with a number of large single oysters scattered in the sample. A heavy 1947 set had attached to the oysters and shells.

There was no recognizable storm damage and recently killed oysters were less than 5 percent of the population. Conchs and drilled oysters were absent.

Meats were fairly good with glycogen being deposited. The gonads were empty of ripe sex products. Food was in the digestive

tract and the crystalline style was present. There were no Polydora mud vesicles.

The fouling was not heavy and shells were relatively clean, although some Bryozoa and a few barnacles, mussels and calcareous tube worms (Serpulids) were attached.

i. Cabbage Reef. Station 9 is located north of Creole Gap on the Mississippi-Louisiana line in 7 feet of water on a hard and shelly reef. Part of the reef is an exposed key. The dredge was dragged for 5 minutes and caught 0.2 of a barrel of bottom material. A few living oysters of all sizes were recovered, but the greater portion of the material was boxes both recent and old. A limited 1947 set was found.

The mortality which represented about one-half the population was quite high in the total sample with most of the boxes among the small sized oysters. Conchs were present and many of the 1947 set were drilled. Except for drilled oysters there were no other signs of the cause of mortality.

The oysters and shells were heavily fouled with Bryozoa, calcareous tubes of Serpulids, barnacles and mussels. All the shells were old and eroded.

j. Cat Island Channel. Station 10 is located east of Cabbage Reef, between Isle au Pitre and Cat Island on the Mississippi-Louisiana line in 25 feet of water. The bottom was hard and shelly with occasional patches of sticky mud. The dredge was dragged for 6 minutes and caught about 0.7 of a barrel of bottom material in which were many large single oysters, locally called "sack" or raw-trade oysters. The 1947 set was abundant and some of this was very recently attached. The small oysters were in clusters caught on the boxes of those killed in 1945. About one-half the sample was shelly trash which included fragments of Pinna shells, sponge rotted Venus and old oyster shells.

Recent mortality, largely confined to the 1947 spat and small oysters, amounted to about 25 percent of the population. No conchs were in the catch but many 1947 spat were drilled. The cause of the mortality among the oysters, except for those drilled, could not be determined. There was no evidence of recent mudding although marsh grass clumps and sticks which may have been washed in by the hurricane were present.

Fouling on the old shells made them quite dirty. Barnacles, Bryozoa and a few mussels were attached, and boring sponge had perforated the old shells. Live large hard clams (Venus) and many crabs,

blue (Callinectes) and mud (Panopeus) were in the catch.

II. Chandeleur Sound

a. Deep Water Pass. Station 11 is located south of Brush Island at the eastern end of Deep Water Pass in 4 to 5 feet of water on bottom which at this time was hard sand with a few shells widely scattered. It was reported to me that this extensive reef was an excellent hard shell, well stocked oyster area prior to the storm. The dredge was dragged in 3 places on the reef with an average time of 5 minutes for each drag. The amount of bottom material caught in the 3 drags was less than 0.05 of a barrel. In the 3 drags only 5 adult oysters were caught, and on the shells and oysters a light 1947 set had attached.

Mortality on the basis of this limited quantity of bottom material would be about 25 percent of the present population, but on the strength of the stated condition of the area before the hurricane, the actual damage and loss was heavy. The reef now is almost completely covered by sand. Conchs were present and among the dead spat were some that had been drilled.

The meats of the 5 oysters opened were only fair, with gonads relatively empty of ripe sex products. Oysters had food in the stomachs and the crystalline style was present. The tissues of the oysters were examined microscopically for the presence of Nematopsis spores and a considerable number was found in the mantle.

Fouling organisms were not abundant on the few shells and oysters recovered.

b. Karako Bay (east side). Station 12 is located close to the east shore of Karako Bay in 4 feet of water, where the bottom, like most of this bay, is hard shelly oyster reef. The dredge was dragged in 3 places on this part of the reef and caught 1.3 barrels of bottom material, mostly live oysters. The population contained many large single oysters, a few small oysters in clusters and an abundant 1947 spatfall. There was a surprisingly small amount of shell trash and debris on this old shelly bottom.

Mortality observed in the catch was very light and equally affected all ages of oysters. Neither conchs nor drilled oysters were seen.

Meats were fairly good with glycogen beginning to accumulate. The gonads were empty of mature sex products. The crystalline style

was present but very little food was in the stomachs. Polydora mud vesicles were scarce.

Fouling was largely by barnacles and mussels. The boring sponge had perforated most of the older shells but at the time of this survey no living sponge was found.

c. Karako Bay, (Middle portion). Station 13 is located in the central part of the bay in 6 to 8 feet of water on hard reef similar to Station 12, except for a few isolated areas of sticky mud. Dredgings were made 4 times for 3 minutes at each drag. In this part of the bay oysters were more abundant than at the eastern side, with half of the dredged material being small live oysters in clusters. Market size oysters were absent. A heavy 1947 set had attached to the shells and old boxes. The reef appeared to have been worked heavily in the past, as many old boxes with broken bills were present.

Meats were still quite thin although some glycogen had accumulated. The gonads had expended most of the ripe spawn. Food was in the stomachs and the crystalline style was present. Exceptionally good new shell growth occurred on these oysters.

Recent mortality was very light and would not exceed 5 percent of the oyster population. Conchs were absent and no drilled oysters were found.

Fouling was about the same as that on the shells from other parts of Karako Bay. Perforations of the boring sponge and clam were numerous in the old shells, and Bryozoa, barnacles, mussels and the boring sponge were present. Crabs, both mud and blue, were abundant although smaller in size than those found in the open waters of the Sounds.

d. Karako Bay, (western portion). Station 13-a is located northwest of Station 13 in 5 to 7 feet of water on bottom that was mostly firm mud with isolated patches of oysters and shells. The dredge was dragged in two different places for about 6 minutes per drag. Live oysters were numerous and about the same distribution according to age as at Station 13. The dredgings caught a similar amount of bottom material per drag although the drags were twice as long. This indicated fewer oysters on the bottom.

Mortality, fouling and condition of meats were about the same as at Station 13.

According to Mr. C. Delacruze and Mr. E. De Sylvey, this reef was abundantly populated with oysters of small size at this time

last year. There are still many small oysters but considerably less than in 1946.

The reef is in comparatively shallow water where storms generally disturb the bottom. In this area it is possible that part of the loose upper layer of bottom material, including oysters, was washed off the reef. If this happened, the lost portion of the population was not found on this survey.

e. Cranetown Bay. Station 14 is located near the "hole" or deep portion of the relatively shallow Bay in 15 feet of water. The hard reef bottom was covered mostly with old, eroded, and broken shells except for a few small areas of soft mud under which could be felt the hard reef. Sounding with a pole disclosed the location of the mudded portions of the bottom. The dredge was dragged for 5 minutes and caught about 0.5 of a barrel of bottom material of which old, eroded shells comprised 90 percent of the catch. Live adult oysters were few in number, only 4 large ones being found. Neither small oysters nor 1947 set were seen.

A few recently mud-killed large oysters were recovered. Mr. Delacruze again reported a heavy crop of "rank" or poorly shaped large oysters on this bottom during 1946. The live and dead oysters now present suggest that a considerable loss has occurred this year.

Records of oysters harvested from the Bay were not available, but the appearance of the shells now on the bottom indicated an intensive dredging activity of recent years. No conchs were found, and drilled shells were absent from the sample.

The meats of the oysters were fairly good with a noticeable glycogen accumulation. The gonads were empty of ripe sex products. Oysters were feeding and the crystalline style was present. The incidence of Nematopsis was heavy in the mantle tissue of the oysters from Cranetown Bay.

Fouling of shells and oysters was not particularly heavy except for the perforation and occurrence of the boring clam which riddled the old shells. At this station was found the only oyster crab (Pinnotheres sp.) seen during the course of this survey of the gulf coast of Alabama, Mississippi and Louisiana. The single specimen was lying in a cavity in the oyster tissue which appeared to have been made by the crab eating away parts of the posterior ends of the palps and the adjoining parts of the gills. The oyster in which it was found was otherwise in a healthy condition.

f. Martin Island. Station 15 is located in a bay formed by Martin and Holmes Islands in 5 feet of water on a bottom of hard shell reef. Many drags of the dredge were made but only 3 at 5 minutes per drag were saved for examination. The catch of one barrel per drag was quite uniform throughout the area. The amount of material examined critically was 3.0 barrels. Most of the catch was live oysters which roughly fell into two classes, (1) large "sack" or raw-trade single oysters, and (2) early 1947 set. Blank shells and boxes were scarce.

No unusual mortality was noticed. Mr. De Sylvey, however, did say that parts of this reef were much more heavily populated with oysters when he was working here in previous years. It was strange that so few small oysters were found in the sample but no evidence of mortality of this class could be found. Conchs were present but no drilled oysters were observed.

Oyster meats were good with "fattening" well advanced. Active feeding was in progress and the crystalline style was present in all oysters opened. The gonads were expended of ripe spawn. Only a few Polydora mud vesicles were found. Nematopsis spores appeared in the mantle tissue. The incidence was the heaviest seen during this survey although the oysters appeared healthy.

Fouling was light, and although old, most of the shells and oysters were clean.

One additional 5 minute drag of the dredge was made near Holmes Island on a small and isolated reef, and caught some oysters, shells and a few boxes. The total catch was only about 0.2 of a barrel of which 60 percent was large oysters. Here, as well as the rest of the Martin Island area, no evidence of storm damage was found.

g. Eloi Bay. Station 16 is located midway between Point Comfort and Deadman Island in 5 feet of water on hard shell reef. The dredge was dragged in 4 places for about 4 minutes per drag, catching in all about one barrel of bottom material. There was a sparse distribution of live oysters on this reef. Small oysters made up the bulk of the limited amount of live material although a fairly abundant 1947 spatfall was on the loose shell and oysters. The shell was old and crumbly. This reef was reported to be depleted in 1946.

Mortality among the adult oysters was negligible, but many, approximately 50 percent of the 1947 set, had died recently. The cause of the spat loss may or may not have been from the effects of the storm. No evidence of the hurricane damage common to other places, such as mud or debris of dying grass or branches of marsh shrubs, was

found. Conchs were present but only a few spat had been drilled.

The meats were only fair and quite thin. Spawning was over and the gonads were relatively empty of mature sex products. Food was in the stomachs and the crystalline style was present.

Fouling was heavy. Bryozoa, hydroids, barnacles and Mogula were encrusted and attached to the shells and oysters. The shells were old, dirty and eroded by the invasion of boring clam and boring sponge.

h. Athanasia Bay. Station 17 is located in the center of Athanasia Bay in 5 feet of water on a bottom composed of a stiff clay-like crust on soft mud. The dredge was dragged for 3 minutes and caught about 3/4 of a barrel of bottom material, mostly oysters of smaller sizes. Some of this was 1947 set. Blank shells were scarce.

No recently dead oysters were found. No conchs were in the sample nor were there any drilled oysters. Polydora mud vesicles were scattered and few. The storm did not seem to have damaged this area.

Meats were fairly good and "fattening" well advanced. The gonads were completely spawned of mature sex products. Food was in the stomachs and the crystalline style was present.

Mussels, barnacles and boring clams were fairly abundant but fouling on the whole was quite light.

Discussion and Summary

Hurricane damage was evident on many of the reefs and planted bottoms in the eastern part of the Louisiana Marshes and the area adjacent to Lake Borgne in Mississippi Sound. Of interest, however, was the lack of pattern in the extent of harm inflicted. Damaged areas were disconnected and interspersed with reefs apparently unharmed.

The area around Grand Island in the extreme western part of Mississippi Sound was the site of the greatest damage. Mud and sand completely obliterated large portions of the natural reefs. The shell plantings in this area also were lost or badly scattered. Cabbage Reef, east of Grand Island and on the southern edge of Cat Island Channel, lost recently about half of a large population of small oysters. The reef between the mouth of Grand Pass and Cabbage Reef was affected similarly.

The areas in Chandeleur Sound seriously affected by the hurricane were in the vicinity of the eastern end of Deep Water Pass. Sand had

covered the reefs and few live oysters were recovered. South of Deep Water Pass at Martin Island, storm damage to the bottom was not readily apparent but Mr. E. De Sylvey, who has dredged the area in the past year said that certain portions had shown a considerable reduction in the oyster population. The reefs in Eloi Bay at the southern limit of the investigation in Chandeleur Sound were not noticeably damaged but 50 percent of a heavy 1947 set had been killed recently.

In the marshes adjoining both Chandeleur and Mississippi Sounds are many large bays where there is intensive oystering for the canning trade. The most important ones were visited in this survey. Karako Bay was sampled thoroughly. This area was not badly harmed except for a portion in the northwestern section where patches of mud were found on the reef. Small oysters and 1947 set were fairly abundant. This present population was reported to be considerably less than was here a year ago. It was also reported that the area was dredged heavily for the 1946-47 trade. Most of the population decrease was more than likely from the dredging operations of the previous year. In Cranetown Bay some hurricane damage was apparent, but again, dredging for the oyster trade seemed to be the principal reason for fewer oysters at present on the reefs. No apparent damage was found in Athanasia Bay.

A shell planting, made west of 3 Mile Bayou (Station 5) by the State of Mississippi in agreement with Louisiana, was not seriously harmed although much of the 1947 set that had attached was now dead.

Suggestions for Rehabilitation

As a result of the hurricane Louisiana lost some oysters and oyster bottom. This destruction undoubtedly will be reflected in a reduced production for the canning trade both in Louisiana and Mississippi for this and perhaps a succeeding year.

The reefs in this State located in Mississippi Sound were hardest hit by sanding and because of this will not recover quickly and naturally. Shelling on the sand is always inadvisable in shallow water and therefore not recommended at this location. However, in 1947 the 40,000 barrels of shells planted on the reefs west of Three Mile Bayou were not sanded. Additional shell plantings could be made contiguous to this area and westward to Cat Island Channel.

In the bays and lakes within the marshes, the oyster bottoms were, for the most part, unharmed except that the oysters and cultch

in certain places had been washed away. Clean shell, however, would profitably supplement the bottom cultch. The excellent cultch available from the steamhouse shell-piles would increase the efficiency of setting wherever it was broadcast. Re-shelling is the economical and reasonable method of bringing these bottoms back to production because the setting incidence is sufficiently high, in all sections examined, to give assurance that in time nature will replace much of the loss.

Figure 1. Locations of sampling stations in Louisiana oyster producing waters, established for a survey of the extent of hurricane damage, 1947.

III. A Report on the Investigation of the Oyster Reefs of the State of Alabama following the Hurricane of September 19, 1947.

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Introduction

Honorable Bert E. Thomas, Director of Conservation of Alabama, requested the Director of the U. S. Fish and Wildlife Service to permit the author to examine the oyster reefs in Alabama to ascertain hurricane damage. The author, accompanied by members of the Seafoods Section of the Alabama Department of Conservation and Dr. Allan F. Archer, State Ecologist, surveyed the oyster reefs. The investigation in Alabama waters began December 1, and was concluded December 6, 1947.

Alabama waters of Mississippi Sound and Mobile Bay were on the northeastern fringe of the hurricane force winds, and the tidal conditions while severe were not as destructive to land installations as recorded in Mississippi. A rise of about six feet over mean high water flooded shore-front buildings and lands in the Bayou La Batre and Bayou Coden sections of Mobile County. Storm damage to oyster bottoms was restricted to the inshore portions mostly composed of marginal type semi-stiff mud in Grand Bay, Isle aux Dames Bay and Portersville Bay. On the western edges of the series of reefs between Cedar Point and Dauphin Island some mud had accumulated and dead oysters were found. The survey extended to the reefs in Mobile Bay proper and Bon Secour Bay but in these areas there was no apparent damage that could be attributed to the hurricane.

Dr. Allan F. Archer, State Ecologist, conducted a short survey of the Alabama oyster reefs on October 27 and 28 to check the damage to the oyster reefs, and reported at that time only limited mortalities and minor recent harm to the oyster bottoms. Most of the damage was from mudding and the sediment and debris brought inshore by the heavy seas. Dr. Archer also reported briefly on his observations made while in company with the author during the first week of December 1947. In the latter report he mentioned that the oyster mortality had increased since his survey of October. This is understandable when it is realized that oysters not killed immediately during or soon after the hurricane may have been injured sufficiently to have been unable to recover. Those oysters were probably considered alive and uninjured at the time of Dr. Archer's first examination.

The State of Alabama planted more than half of its shells and seed in the area most severely affected by the storm. In 1947 the State, with some assistance from the private oyster dealers, planted 19,040 barrels of seed oysters and 12,743 barrels of shells. The seed was obtained from two natural reefs in Mobile

Bay, King Bayou and Buoy, which at the time of this survey still had ample small oysters that could be used to repair the loss on the planted beds in Mobile County. The shells planted this past year represented 30 percent of the shells accumulated at the oyster packing houses during the 1946-47 marketing season and required by law to be put back by the companies using the oysters. To plant the seed involved a cost of $.37 per barrel, and to distribute the shells on the bottom cost $.30 per barrel. For the shell planting the labor involved was estimated at $.20 per barrel and the shells on the shell piles could be purchased for $.10 per barrel for rehabilitation. The reefs receiving the shells and seed during the spring and summer of 1947 and the quantities planted are shown in Table 1.

Equipment and Methods used in this survey

The equipment and methods employed in the survey of the oyster bottoms of all the Gulf States affected by the hurricane were used in Alabama. The sampling of the oyster bottoms was accomplished by the use of the general commercial size and weight dredge operated with mechanical winders from a regular dredge boat. The dredge was the standard 42 inch, 17 tooth, heavy frame instrument with a chain link and cord net bag to hold the bottom material. The capacity of the bag when full was approximately one barrel or three bushels of material. When dredging the boat maintained a speed of about 4 miles per hour.

In addition to the commercial dredge boat the State of Alabama furnished a State Patrol vessel as a floating headquarters with accommodations for sleeping and laboratory facilities. The patrol vessel followed the sampling boat throughout the course of the survey.

The locations of the principal reefs were known to the members of the Seafoods Section of the Department of Conservation and in a general way to the author who has examined the Alabama oyster bottoms on several previous occasions (see Special Scientific Report No. 29, U.S.F. W.S. 1945). When on the reef or planted bottom the consistency was carefully sounded with a pole and the type and relative stiffness of the bottom material was ascertained and recorded. The bottom consistency was classified as follows:

Table 1

State of Alabama

Seed and Shell Transplanting Program 1947.

Location	Barrels Seed	Type Bottom	Barrels Shell 1/	Type Bottom
Mobile County				
Grand Bay	2,000	Semi-stiff mud	1,500	Semi-stiff mud
Isle aux Dames Bay	1,500	" "	1,200	" "
Portersville Bay	3,500	" "	10,043	" "
" "	3,500 2/	" "		" "
Baldwin County				
Little Point Clear	2,000	Hard Reef		
Fish River	2,500	" "		
Bon Secour	2,000	" "		
Bayou Cour	2,040	" "		
Total	19,040		12,743	

1/ This shell represents 30 percent of the 1946-47 production.

2/ Seed transplanted at the expense of the oyster dealers.

Table 2.

Salinities, Temperatures and Turbidity of the marine waters in Alabama.

Station	Location	Date 1947	Depth in ft.	Salinity °/oo	Temp °C	Turbidity
	Mississippi Sound	Dec.				
1	Grand Bay	1	5	27.11	-	light
2	Isle aux Dames Bay	1	5-6	28.26	14.2	clear
5	Portersville Bay	2	4-5	27.89	13.2	light
17	Half Moon	5	5	20.08	16.2	light
18	Heron Bay	5	5	18.59	-	heavy
19	Heron Bay	5	5	14.14	-	light
20	South of Cat Island	5	5	19.34	16.9	light
	Mobile Bay					
11	White House	4	15	17.75	15.0	light
12	Kings Bayou	4	8	17.75	14.4	light
15	Cedar Pt. Reef	5	6	21.09	16.0	moderate
	(S 1) Dog River	5	8	5.12	15.0	clear
	(S 2) Buoy 36	5	10	11.71	-	moderate
	(S 3) Buoy 22	5	10	15.75	16.0	heavy
	(S 4) Cedar Pt. Reef					
	Bon Secour Bay					
6	Little Point Clear	3	7	30.77	15.0	moderate
8	Bon Secour Reef	3	6	20.45	15.2	moderate
9	Bayou Cour Reef	3	7	26.06	16.0	heavy
10	Klondike	4	11	18.80	15.0	moderate
14	Great Point Clear	5	20	20.45	14.8	clear

Table 3.

A Summary of the Dredging and Material Collected in Alabama.

Station	Depth	Type of Bottom	Number Drifts	Time per Drift	Area Covered By dredging in Sq. Yards	Total Amount Material Dredged	Amount Material per 5 min. Drift	Conchs	Market	Live Oysters: Small	Live Oysters: Spat	Recent Oyster Mortality Per cent Dead
Mississippi Sound												
1 (a)	5'	S.	3	5	2,055	0.17	0.06	present	scarce	scarce	few	90%
2 (b)	5'	S.	8	3	3,288	1.50	0.31	many	few	few	few	85%
3 (c)	5'	S-St.	3	5	2,055	2.50	0.83	many	few	few	few	90%
4 (d)		St. R.	3	5	2,055	1.50	0.49	present	scarce	scarce	scarce	75%
5 (e)	4'	S-St.R.	5	8	5,480	0.83	0.10	present	none	scarce	some	50%
16 (f)	6'	H. R.	3	3	1,233	3.00	1.65	0	many	many	many	10%
17 (g)	5'	St. H.R.	2	3	822	0.55	0.45	0	many	many	few	10%
20 (h)	5'	S. St.R.	2	3	822	0.50	0.41	present	many	many	few	05%
Mobile Bay												
11 (a)	15'	H. R.	3	5	2,055	1.50	0.50	0 1/	many	few	many	05%
12 (b)	8'	H. R.	3	4	1,644	3.00	1.21	0	few	many	many	05%
13 (c)	8'	H. R.	3	4	1,644	3.00	1.21	0	few	many	many	05%
14 (d)	20'	St.H.R.	3	3	1,233	1.00	0.55	0	few	many	many	10%
15 (e)	6'	H.R. 2/	2	3	822	2.00	1.65	present	many	many	many	05%
Bon Secour Bay												
6 (a)	6'	H. R.	4	5.5	3,014	4.50	1.01	many	many	many	few	05%
7 (b)	6'	St.H.R.	2	3	822	1.00	0.80	0	many	few	0	10%
8 (c)		St.H.R.	2	4	1,096	1.00	0.62	present	few	many	few	10%
9 (d)		H. R.	2	4	1,096	2.00	1.24	present	many	few	few	10%
10 (e)	11'	H. R.	2	3	822	0.67	0.55	many	0	many	many	10%

1. Drilled oysters were found in the sample.

2. A small rim of soft mud was on the outer edge of the reef.

Classification	Symbol[1/]	Description
Hard reef	H.R.	Solid oysters and (or) shells.
Sticky reef	St. R.	Oysters and shells on or in stiff mud.
Sand	Sd.	Usually without oysters or shells.
Sticky mud	St. M.	Stiff mud without oysters or shells.
Soft mud	S. M.	Pole penetrates easily - no oysters.

With this data it was possible to determine whether or not recent mudding had covered the reef or planting.

Water samples were taken in all the regions and at most of the individual stations during this survey. A bottom water sampler was used and all samples were bottom water. The collected sample was transferred to a citrate bottle with a rubber gasket stopper to be saved for salinity determination at the end of the cruise. The specific gravity was determined by hydrometers certified by the U. S. Bureau of Standards and converted by the use of the Knudsen Tables to salinity in parts per thousand. The relative turbidity or suspended silt content of each sample was noted when the salinity was determined.

The bottom temperatures were taken frequently, but not at every station, by using a standardized reversing thermometer reading to the nearest 0.2 degree Centigrade.

When dredging for samples of bottom material, the following procedure was followed: (1) the length of the drag was timed; (2) the volume of the catch was estimated in barrels for each drag; and (3) the contents of the catch were evaluated to the percent of live oysters, dead oysters (boxes), shells and debris, and a listing of the principal predators and fouling organisms. Some oysters were opened at each station or sampling area to determine the condition of the meats, the presence or absence of the crystalline style, the amount of gonad material available and the condition of the inner surface of the shells with regard to the occurrence of the mud blisters of Polydora and the perforations made by the boring sponge or boring clam. Oysters counted as dead were only those whose empty shells were still joined by the horny hinge or ligament. The dead oysters or "boxes" were examined for evidence of drilling by the conchs.

The approximate density of the oyster population was calculated on the basis of the amount in barrels dredged per unit area. The

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1/ Symbols used in Table 3.

area covered by the dredge was arrived at by determining the square yards the dredge was dragged per unit time. Comparing the catch in barrels by this method made it possible to tell the relative distribution of oysters and other bottom material on the oyster reefs and planted bottoms in Alabama examined during the course of this survey. The dredge used in the survey scraped 34 square yards per minute when dragged at the rate of 4 miles per hour. The details of the catch will be discussed for each reef and sampling area when the individual oyster bottoms are analyzed in another part of this report.

Through the efforts of Mr. Sydney Landry, Chief Seafoods Inspector, the records of the State cultivation program were assembled to evaluate the 1947 seed and shell plantings. This information is shown in Table 1. From these records some of the loss from the hurricane was definitely determined.

Salinity, Temperature and Turbidity

At the time of this survey the waters of Mississippi Sound and its north shore tributaries had sufficiently high salinity to maintain oysters. In the vicinity of Isle aux Dames Bay, Station 2, the most saline waters were found, and well inshore in Heron Bay, Station 19, the least. There was a tendency for the salt content to increase westward of Mobile Bay. In the Bay a very definite salinity gradient was shown decreasing from the mouth northward. This was from Cedar Point northward to Dog River where the salinity decreased from 21.09 to 5.12 parts per thousand. The productive oyster reefs were located where the salinity ranged from 21.09 to 15.75 parts per thousand, which was sufficiently high to cause no trouble to the existence of oysters. The northernmost oyster reef, Station 11, called White House, was in waters of a salinity of 17.75 parts per thousand. In Bon Secour Bay, east of Mobile Bay, salinities ranged from 30.77 parts per thousand at the southernmost station, Little Point Clear Reef, Station 6, to 20.45 parts per thousand at Station 14, Great Point Clear Reef. At Klondike Reef, 15 miles north, a slightly lower salinity than the range listed above for Bon Secour Bay was found. This latter salinity, 18.8 parts per thousand was still high and adequate for oyster existence.

Temperature of the water on the bottom ranged from 13.2 degrees Centigrade in Portersville Bay to 16.2 at Station 17, called Half Moon, in Mississippi Sound. The range was too small to have any marked effect on the oysters in the area.

The waters showed a wide range of turbidity which, for the most part, was light. Considerable silt was found in only 3 of the 18 stations. On the other hand only 3 stations had relatively clear water. The turbidity was caused by a fine brownish silt that settled out very slowly only when the samples were allowed to stand undisturbed for a long time. No evidence of the silt now present in the water could be found in the shell cavities of the living oysters examined during this survey. The reports by persons in the area during the hurricane indicated a heavy amount of silt and debris was present at that time. The mudding of the bottom also points to this same conclusion. The salinities, temperatures and turbidity of these waters are shown in Table 2.

There seemed to be no direct correlation in the distribution of conchs with the present salinity picture of the area. The fact that conchs were absent from the samples dredged north of Cedar Point in Mobile Bay indicates that their spread is checked by the spring flood conditions so often recorded for Upper Mobile Bay in the past. The distribution and damage from conchs will be discussed when the condition on the individual reefs are explained in detail in another part of this report.

Description of the Alabama Oyster Reefs

Most of the week of December 1, 1947, was spent in the field sampling by commercial dredge the principal reefs in Alabama waters. To cover the area 18 sampling stations were visited, the locations of which are shown in Figure 1. From 2 to 8 dredgings were made at each station, ranging from 3 to 8 minutes, with an average of about 5 minutes per drag. The total area actually covered in dredging was about 8200 square yards. For comparison convenience the amount of bottom material caught per drag was adjusted to the amount collected per 5 minute drag. The average amount of material caught per 5 minute drag was 0.77 barrels with the amount per drag ranging from 0.06 to 1.65 barrels. A summary of the results of dredging is shown in Table 3.

For a more comprehensive picture of the conditions on the reefs it was thought best to give a narrative description of the individual station areas. The stations will be considered in groups arbitrarily arranged by geographical units, namely, Mississippi Sound, Mobile Bay, and Bon Secour Bay.

I. Mississippi Sound and Tributaries

a. Grand Bay. Station 1 is located at the extreme western part of the Alabama portion of Mississippi Sound, close to the Alabama-Mississippi line in 5 feet of water. Grand Bay is a shallow indentation of Mississippi Sound with a very limited fresh water drainage so the water condition resembles that of the Sound. The bottom was mostly semi-stiff mud with a soft mud upper layer. Before the hurricane the State of Alabama made a mixed planting of 2,000 barrels of seed oysters and 1,500 barrels of steam house shells. The oysters and shells were in a narrow strip at the entrance of the bay. The dredge was dragged in 3 different places on the plantings and in all only about 1/6 of a barrel of bottom material was caught, mostly mud-blackened boxes of all sizes. Live oysters were scarce. They included 3 market size, 3 small and 24 recent set.

The mortality was great and recent; it may be conservatively estimated at about 90 percent of the population. The mortality was undoubtedly caused by mudding which may well have happened when rough water rolled in the surrounding soft bottom. One large conch was in the sample but no drilled oysters were found.

The meats were poor and thin. The inner surfaces of the shells of the oysters opened had a heavy incident of Polydora mud vesicles.

b. Isle aux Dames Bay. Station 2 is located east of Point aux Pins which separates this Bay from Grand Bay. This is a shallow water bay with depths ranging from 5 to 6 feet. On the outside edge the bottom was mostly soft mud which stiffened to a hard reef on the inshore part of the plantings. The stiff mud and hard gravel was formed in a 4 to 6 inch crust over deep soft mud. The dredge was dragged in 8 different places for about 3 minutes at each drag. In all about 1½ barrels of bottom material was caught for examination. Most of the sample was shell and boxes with about 1/6 barrel of live oysters of all sizes including 1947 spat. About 25 percent of the live oysters were of market size.

The estimated mortality, about 85 percent of the population, was primarily among smaller oysters. Mudding was by far the major cause of the recent mortality although damage from the many conchs present in the sample was quite severe. The older shells and oysters were badly infested with the boring clam. A few mussels were on the clusters of shells and oysters.

The meats examined were poor, thin, and discolored a dark brown. The crystalline style was absent and gonads had no ripe

sex products. Polydora was abundant on the inner surfaces of the shells.

c. Portersville Bay, natural reef off Bayou Coden. Station 3 is located off the mouth of Bayou Coden and east of the tip of Isle aux Herbes in 5 feet of water. The bottom was semi-stiff mud in a crust over soft mud. The dredge was dragged in 3 different places for 5 minutes at each drag. The total quantity of the material amounted to 2½ barrels consisting mostly of large boxes. Only a few live oysters of all sizes were present. The 1947 set was relatively good.

Mortality was severe, especially among the large oysters. Most of the oysters were killed by recent mudding. Smaller oysters and spat suffered to a somewhat lesser degree by the same cause. The smaller oysters and spat had the conch preying on them and a considerable number of these oysters were found drilled. The recent mortality from all causes was about 90 percent of the population. Many conchs of all sizes from 1/2 inch to 2 inches were found in the sample.

Fouling organisms were abundant. Bryozoa covered many shells. Martesia had invaded most of the older oysters and larger shells. A few barnacles and mussels were attached to the oysters and shells. Mud crabs were present in the boxes and crevices of the clusters.

Oyster meats were quite good and accumulating some glycogen. The gonads were empty of mature sex products and the crystalline style was present. Polydora mud vesicles were rare on the inner surfaces of the shells of the opened oysters.

d. Portersville Bay east of Coffee Island (Isle aux Herbes). Station 4 is located at a place planted by the State and the industry in 1947 with shells and seed oysters. The bottom was composed of stiff mud and lumps of shell gravel interspersed with sloughs of soft mud. The dredge was dragged in 3 different places for 5 minutes per drag catching about 1½ barrels of bottom material which included few live oysters, collected only from broken shell bottom (shell gravel).

Mortality was quite high especially among the large oysters. The blackened boxes indicated that these oysters had been covered by mud and smothered. The clean inner surfaces of these boxes revealed that the mortality was recent. Conchs were numerous and damage by them was relatively great among the smaller oysters and spat.

Fouling was about the same as at Station 3.